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# USSR Report

SPACE



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14 November 1984

## USSR REPORT

## SPACE

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MANNED MISSION HIGHLIGHTS

COMMENTS ON ROLE OF FEMALE COSMONAUTS, OVERCROWDING ON 'SALYUT-7'

Moscow TRUD in Russian 31 Jul 84 p 3

[Article by I. Melenevskiy special correspondent at the Flight Control Center]

[Abstract] The article gives an account of activities at the Flight Control Center during the return to Earth of cosmonauts Vladimir Dzhanibekov, Svetlana Savitskaya and Igor' Volk--the members of the latest visiting crew on board the orbiting station "Salyut-7".

General-Lieutenant of Aviation Vladimir Aleksandrovich Shatalov, director of cosmonaut training, and Doctor of Technical Sciences K. P. Feoktistov are quoted in regard to experience amassed during the joint work of this crew and the three-member primary crew of the "Salyut-7" station. Shatalov commented as follows on the role and capabilities of women in space missions: "As has been seen, conditions on board orbiting stations of the second generation are such that a woman can work in sufficiently comfortable conditions there. Svetlana Savitskaya's two flights have confirmed this eloquently. When third-generation stations appear on which living and working conditions are still better, other mixed crews will continue work on board them. Of course, there will always be a certain division of labor, in my opinion. Thus, it is still best for the installation of bulky structures and the unloading of 'Progress' spacecraft to be done by men. On the other hand, onboard medical personnel and meteorologists can be women. I also don't rule out the possibility of flights on stations by crews consisting entirely of women. The scientific program is becoming progressively necessary to send into orbit persons who are more and more 'narrowly' specialized. Among them are a considerable number of women. We are now convinced that they can work in orbit just as successfully as men."

With regard to practical problems encountered by the visiting crew and the significance of the latest space welding experiments in this connection, Feoktistov related: "Overcrowding already was sensed when six persons were working on board the station. When I. Volk wanted to run around the track in orbit, this proved impossible: he would have disturbed the rest of the cosmonauts if he had. This means that spacecraft with larger interiors are needed. Placing such spacecraft into orbit is difficult and expensive. It is simpler to assemble them in space. The work done by the visiting crew demonstrated the possibilities for such assembling operations."

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FURTHER COMMENTS ON 'SALYUT-7' WELDING EXPERIMENT, OVERCROWDING

Moscow KOMSOMOL'SKAYA PRAVDA in Russian 31 Jul 84 p 2

[Article by A. Tarasov special correspondent at the Flight Control Center]

[Abstract] The article records conversations between personnel of the Flight Control Center (TSUP) and members of the crew of the spaceship "Soyuz T-12" during the cosmonauts' return from the orbiting station "Salyut-7". A number of specialists who were at the center are quoted in regard to the significance of experiments which members of this crew carried out during their space mission.

Vladimir Petrovich Nikitskiy, a TSUP specialist and one of the organizers of the welding experiment which members of the visiting crew performed outside the space station, mentioned problems which he and his colleagues had to solve in this connection. For example, the station's onboard voltage had to be converted into voltage sufficient to power the electron gun of the open-space welding unit; methods had to be developed for controlling, in space, the high temperatures generated by this unit and protecting the fabric of the cosmonauts' space suits against them; and the size and weight of units employed in the experiment had to be minimized.

Valdimir Aleksandrovich Shatalov, director of cosmonaut training, and cosmonaut Konstantin Petrovich Feoktistov, an experienced project designer, are identified as the heads of a group that is designing space super-structurals at the TSUP. Feoktistov mentioned that physical-conditioning exercises on board "Salyut-7" were hampered by the presence of six cosmonauts on board the station at one time. He explained that such exercises shake structures of the station, which disturbs delicate experiments that are in progress. Welding methods of the type used in the latest experiments open up possibilities for solving this problem, according to Feoktistov. In the future, they might be used to assemble large gymnasium complexes in orbit for cosmonauts, for example.

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TASS REPORTS COSMONAUTS IN ORBIT 175 DAYS

Moscow KRASNAYA ZVEZDA in Russian 1 Aug 84 p 1

[TASS Report]

[Text] Flight Control Center, July 31. The tour of duty of cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov in near-Earth orbit has been in progress for 175 days.

Today's agenda on board the complex calls for checking the functioning of scientific apparatus and preparing it for operation, a number of astrophysical and technical experiments, and washing the station's rooms.

An experiment is being continued for abiogenic synthesis of components of nucleic acids in conditions of open space. An instrument called "Meduza" with specimens that are under study was installed on the outer surface of the "Salyut-7" station during Vladimir Dzhanibekov's and Svetlana Savitskaya's egress into space.

Following the completion of the program of joint research with the crew of the visiting expedition, yesterday was a day of rest for Leonid Kizim, Vladimir Solov'yev and Oleg At'kov. Meetings with their families were organized for them in the course of several periods of radio and television communications.

The condition of the cosmonauts' health is good, and they are feeling well.

The flight of the orbiting complex "Salyut-7"--"Soyuz T-11" is proceeding normally. Its orbit parameters at the present time are: maximum distance from the Earth's surface--387 kilometers; minimum distance from the Earth's surface--343 kilometers; period of revolution--91.6 minutes; inclination--51.6 degrees.

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GEOPHYSICAL AND MEDICAL STUDIES CONTINUE ABOARD 'SALYUT-7'

Moscow KRASNAYA ZVEZDA in Russian 4 Aug 84 p 1

[TASS Report]

[Text] Flight Control Center, August 3. The prolonged orbital flight of Leonid Kizim, Vladimir Solov'yev and Oleg At'kov is continuing on board the scientific station "Salyut-7".

The crew's program of work during the days just past included geophysical and medical studies, routine preventive measures on board the station, and the preparation of equipment and apparatus for upcoming experiments.

In accordance with assignments from specialists in various branches of the economy, the cosmonauts have performed their latest series of visual and instrumental observations of the Earth's surface. In line with the program of geophysical research, an experiment has also been carried out for the purpose of determining the density of aerosol layers of cosmic origin in the Earth's atmosphere. This experiment was performed with the aid of an electronic photometer and consists in measuring the brightness of stars as they cross layers of aerosols.

A number of medical studies have been made for the purpose of evaluating the condition of the crew's health and working fitness, particularly studies of the bioelectric activity of the heart in conditions of rest and of the reaction of blood circulation to measured amounts of physical exertion. According to results of this examination, the cosmonauts are in good health. The commander's pulse rate is 66 beats per minute, the flight engineer's 68 beats per minute and the cosmonaut-researcher's 60 beats per minute. Their arterial pressures are 110 over 70, 115 over 65 and 110 over 75 millimeters of mercury, respectively.

The onboard systems of the orbiting scientific research complex "Salyut-7"--"Soyuz T-11" are functioning normally.

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## COSMONAUTS PERFORM EVA FOR FUEL LINE REPAIR

Moscow KRASNAYA ZVEZDA in Russian 10 Aug 84 p 1

[TASS Report]

[Text] Flight Control Center, August 8 (TASS)--In accordance with the designated flight program, Leonid Kizim, commander of the crew of the orbiting complex "Salyut-7"--"Soyuz T-11", and flight engineer Vladimir Solov'yev made a sixth egress into open space today.

They opened a hatch of the station and went outside it at 12:46 p.m., Moscow time.

The cosmonauts removed a portion of the heat-shield coating on one end of the station's equipment compartment and shut off a pipe of a fuel line, with the aid of a special device.

Before returning to the station, the cosmonauts removed a fragment of a solar-battery panel for subsequent analysis by specialists on Earth.

The crew's commander and flight engineer returned to the station after carrying out all of the planned operations. The time that they spent in open space was five hours.

Cosmonaut-researcher Oleg At'kov, who was inside the station, monitored the functioning of onboard systems and checked on how his comrades were feeling. The condition of the health of the orbiting complex's crew is good.

The successful completion of complex, multiple-stage installation operations in open space was preceded by the development of methods for performing these operations, the designing and production of special tools, and underwater training exercises for the cosmonauts in a tank.

For the first time in the practice of manned flights, cosmonauts have made six egresses into open space in the course of a single mission. Complex installation work was carried out during these egresses, whose total duration was 22 hours and 50 minutes.

**Experience acquired by Soviet cosmonauts and specialists in the course of performing these unique operations in conditions of open space will be used in the development and operation of orbiting scientific complexes.**

**FTD/SNAP  
CSO: 1866/25**

## SPECIAL TOOLS USED BY COSMONAUTS IN EVA

Moscow PRAVDA in Russian 9 Aug 84 p 6

[Article by A. Pokrovskiy special correspondent at the Flight Control Center]

[Abstract] The article provides commentary on original operations which cosmonauts Leonid Kizim and Vladimir Solov'yev have performed in open space during their current mission on board the orbiting station "Salyut-7".

Particular attention is devoted to the preparation and methods of operations which the two cosmonauts carried out during their sixth and latest egress from the station. An original tool container reportedly was provided for these operations. O. Tsygankov, one of the engineers who took part in the development and testing of new tools for repair work that was done during this egress, related that a fuel line made of stainless steel was to be sealed shut in the course of one operation. Unique equipment, including a hand-held pneumatic press, was developed on Earth for this operation while Kizim's and Solov'yev's mission was in progress. This pneumatic unit, which includes a cylinder containing air under a pressure of 250 atmospheres, is said to be capable of exerting a force of 5 tons. Cosmonaut Vladimir Dzhanibekov was given special training in the use of the new tools, and he subsequently instructed Kizim and Solov'yev during his most recent stay on board "Salyut-7". A television film, photographs, methodological directions and other aids were also provided for instructional purposes. During the open-space operation itself-the fuel line was flattened by compressed air from the pneumatic unit. This method is aimed at ensuring that the line remains sealed shut for the duration of the space station's flight.

A brief description is given of another operation which the cosmonauts performed during their egress. The author of the article was shown a new tool which was developed for this operation. This tool reportedly enabled the cosmonauts to cut out and remove a portion of the station's solar-battery elements without touching them with their hands. The specimen that was removed was to be delivered to Earth for study by specialists who are investigating effects of space factors on battery elements. Mention is made, in conclusion, of the use of new types of industrial electron accelerators in the development of radiation-resistant materials for work outside space stations. It is recalled that an accelerator, the ELT-1.5, was used to perfect a halyard cable which cosmonaut Aleksey Leonov employed during his first egress into open space. Newly invented accelerators were subsequently employed in the development of materials for the space suits worn during the latest egresses.

## RESULTS FROM 'SALYUT-7' BIOMEDICAL RESEARCH

Moscow MEDITSINSKAYA GAZETA in Russian 8 Aug 84 p 4

[Article by V. Pishchik correspondent]

[Abstract] The article reports on results of the first six months of the space mission of cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov on board the orbiting station "Salyut-7". Doctor of Medical Sciences A. I. Grigor'yev, director of the Institute of Medical-Biological Problems of the USSR Ministry of Public Health, is quoted in regard to preliminary results of medical-biological research and experiments which the cosmonauts have been conducting.

Comparing this mission with earlier ones, Grigor'yev related that the presence of physician At'kov on board the station has made it possible to lengthen the intervals separating days on which comprehensive medical examinations are performed and to conduct medical research on practically any day. Studies of the cardiovascular system take up a larger portion of the flight program than during any previous mission. For the first time in space, the method of load tests has been employed to evaluate calcium metabolism, using the "Biokhim" instrument. Studies of the level of immunoglobulins in blood serum are expected to aid research of changes in immunologic reactivity that have been noted in participants in certain prolonged space missions.

Grigor'yev mentioned that another substantial portion of the cosmonauts' research program is reserved for study of the functioning of analyzers, particularly of the organ of vision. Studies of the state of oculomotor function and of features of vestibular-visual interaction are called potentially significant for purposes of preventing motion sickness during flight and preparing recommendations for the performance of visual observations by cosmonauts. Commenting on the more rigorous physical-conditioning regimens which the "Salyut-7" crew is following, Grigor'yev mentioned that the cosmonauts are performing regular exercises aimed at maintaining the muscular strength of the arms and the shoulder girdle. These exercises have been used also for conditioning purposes prior to egresses into open space.

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## PRESS CONFERENCE ON RESULTS OF 'SOYUZ T-12' MISSION

Moscow IZVESTIYA in Russian 11 Aug 84 p 2

[Abstract] The article is a report on a press conference for Soviet and foreign journalists which was held in Moscow on August 10. This conference was devoted to results of the space mission of cosmonauts Vladimir Dzhanibekov, Svetlana Savitskaya and Igor' Volk--the crew of the spaceship "Soyuz T-12" and the most recent visiting crew on board the orbiting station "Salyut-7".

Summaries are given of remarks made by the cosmonauts and other participants in the press conference, among whom were prominent scientists and representatives of space-research organizations. V. A. Kotel'nikov, vice-president of the USSR Academy of Sciences, hailed the successful outcome of the space mission and recalled some of its most memorable events. Dzhanibekov had particular praise for the preparation and support of the mission and for his crew's performance of research and experiments in conditions of an extremely tight schedule.

Savitskaya commented on work she did in open space with a unitized hand tool, relating that she first cut a titanium specimen 0.5 millimeter thick and then welded specimens 1 millimeter thick. She called the welds obtained in space conditions equal to good industrial specimens in outward appearance, at least. She reported that the visiting crew returned to Earth 60 ampoules containing fractions of biological preparations which were purified in the course of the "Tavriya" experiments, together with photographic materials and other data from these experiments.

Volk mentioned that the crew's program allotted 50 percent more time for scientific and technical experiments than programs of earlier missions. The experiments which he called most interesting and significant were ones in which the crew's working fitness was studied with the aid of the "Balaton", an instrument developed by Hungarian specialists, and experiments for studying effects of outer space on the permeability of microorganisms' cell membranes and other characteristics of microorganisms' vital activity, which were prepared by Soviet and French specialists. Volk also stressed the economic importance of the "Tamponazh" experiment, which was aimed at clarifying the mechanism of stages in the solidification of cement-like binding solutions.

**Specimens of suspensions which were prepared in the course of this experiment hardened on board the space station over a period of 10 days. These specimens were subsequently returned to Earth and turned over to specialists for study.**

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TASS REPORTS LAUNCH OF 'PROGRESS-23' CARGO SHIP

Moscow PRAVDA in Russian 15 Aug 84 p 2

[TASS Report]

[Text] In line with the program for ensuring the further functioning of the orbiting scientific station "Salyut-7", the automatic cargo spaceship "Progress-23" was launched from the Soviet Union on August 14, 1984, at 10:28 a.m., Moscow time.

The purpose of the ship's launching is to deliver materials that are subject to depletion and various cargo items to the orbiting station.

The "Progress-23" spaceship was placed into an orbit with the parameters: maximum distance from the Earth's surface--267 kilometers; minimum distance from the Earth's surface--194 kilometers; period of revolution--88.8 minutes; inclination--51.6 degrees.

According to telemetry data, the onboard systems of the automatic cargo ship are functioning normally.

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**'PROGRESS-23' DOCKS WITH 'SALYUT-7'**

Moscow SOVETSKAYA ROSSIYA in Russian 17 Aug 84 p 1

[TASS Report]

[Text] The automatic docking of the cargo spaceship "Progress-23" with the manned orbiting complex "Salyut-7"--"Soyuz T-11" was accomplished on August 16, 1984, at 12:11 p.m., Moscow time.

The mutual search, approach, rendezvousing and docking of the spacecraft were executed using onboard automation. These processes were monitored by the Flight Control Center and the crew of the orbiting complex: cosmonauts Kizim, Solov'yev and At'kov. The cargo ship docked with the station on the side where its equipment compartment is located.

The "Progress-23" ship delivered into orbit fuel for the station's combined engine assembly, equipment, apparatus and materials for conducting scientific research and for the crew's life support, as well as mail.

According to the crew's reports and telemetry data, the onboard systems of the scientific research complex "Salyut-7"--"Soyuz-T-11"--"Progress-23" are functioning normally.

Cosmonauts Kizim, Solov'yev and At'kov are feeling well.

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## INNOVATIONS IN 'PROGRESS' SEPARATION, 'SOYUZ' RENDEZVOUS

Moscow PRAVDA in Russian 17 Aug 84 p 3

[Article by V. Blagov deputy flight director, USSR State Prize laureate]

[Abstract] Describing the work of the Flight Control Center at different times during the present mission on the orbiting station "Salyut-7", the author notes two things that differed from past procedures.

The first innovation was the separation of a cargo ship, "Progress-22", from the station without firing engines. The separation of the spacecraft was accomplished with spring mechanisms. The author explains that this was done by way of an experiment, to check whether any products of combustion from the burn of the engine settle on surfaces of the solar batteries and thereby reduce their efficiency. Following the 'clean' separation of "Progress-22", the crew oriented the station in different ways in relation to the sun. It is said that no differences were detected in the output of the solar batteries as a result of the new method as compared with the old one.

The second innovation pertained to the rendezvousing of the manned ship "Soyuz T-12" with the station. It is said that for the first time, all data from the video display of the arriving spaceship were transmitted not only to the control center, but also to the station. The author says this makes control a mutual process and thereby more reliable, and predicts that this newly tested TV channel may be used in the future for exchanging other kinds of information.

The author also relates that the last (sixth) EVA performed by cosmonauts Kizim and Solov'yev to shut off a line of the "Salyut-7" engine's backup fuel system was initially planned to be done by members of the "Soyuz T-12" visiting crew. Kizim and Solov'yev were successful in arguing that their experience from five previous EVAs made them the logical ones to perform this task.

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COSMONAUTS UNLOAD CARGO, BOOST STATION ORBIT

Moscow IZVESTIYA in Russian 21 Aug 84 p 4

[TASS Report]

[Text] Flight Control Center, August 20. Leonid Kizim, Vladimir Solov'yev and Oleg At'kov are working in near-Earth orbit for the 195th day.

Last week, the work program of the drew of the scientific research complex included medical examinations and biotechnology and geophysical experiments.

Another cycle of studies of the cosmonauts' cardiovascular systems was performed, using the method of ultrasonic probing. Data that were obtained were transmitted to Earth during periods of television communication.

In line with the space biotechnology program, an experiment was performed in the new electrophoretic unit "Genom" for the purpose of separating large fragments of molecules of DNA--a carrier of genetic information of living organisms.

Observations and photography of various areas of our country were continued within the framework of the program for research of the Earth's natural resources and study of the environment. These areas included the Crimea, Krasnodar Kray, the Caspian lowlands, republics of Central Asia and territories adjoining the Baykal-Amur Railroad.

The unloading of the transport spaceship "Progress-23" is continuing. The cosmonauts have moved containers of food, equipment, new instruments and scientific apparatus into the station, replaced regenerators of the system for maintaining the composition of the gaseous atmosphere, and pumped drinking water from a tank of the cargo ship into the station's tanks.

A correction of the manned complex's trajectory of movement has been executed, using the engine of "Progress-23". The complex's orbit parameters at the present time are: maximum distance from the Earth's surface--387 kilometers; minimum distance from the Earth's surface--351 kilometers; period of revolution--91.7 minutes; inclination--51.6 degrees.

The station's combined engine assembly was refilled with oxidizer from tanks of the cargo ship today.

In the course of the day, the cosmonauts are doing preventive work on individual onboard systems, performing experiments for measuring parameters of the atmosphere near the orbiting complex, and conducting observations and photography of the Earth's surface.

The work in near-Earth orbit is proceeding in accordance with the planned flight schedule.

The condition of the cosmonauts' health is good, and they are feeling well.

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**'GENOM' ELECTROPHORESIS EXPERIMENT ON 'SALYUT-7'**

Moscow VECHERNYAYA MOSKVA in Russian 25 Aug 84 p 1

[TASS Report]

[Text] Flight Control Center, August 24, Leonid Kizim, Vladimir Solov'yev and Oleg At'kov are continuing to carry out planned research and experiments on board the manned complex "Salyut-7"--"Soyuz T-11"--"Progress-23".

During the days just past, the crew worked on unloading the transport spaceship, carried out medical examinations and performed technical and geophysical experiments.

In line with the space biotechnology program, a cycle of studies aimed at separating fragments of molecules of DNA, the carrier of genetic information of living organisms, has been completed in the electrophoresis unit "Genom". The course of these experiments was recorded by means of photography in ultraviolet light. About 700 samples of DNA fractions were run off for subsequent analysis in laboratory conditions.

In accordance with the station's refueling schedule, fuel from tanks of the cargo ship was pumped into tanks of the station's combined engine assembly today.

In the course of the day, the cosmonauts are putting used equipment into an emptied compartment of the "Progress-23" spaceship, performing preventive maintenance on individual systems of the station, and preparing scientific apparatus for upcoming research. Also planned is an examination of the cosmonauts' cardiovascular systems, using the ultrasonic apparatus "Ekhograf".

According to the crew's reports and telemetry information, the onboard systems of the station and both spaceships are functioning normally.

Leonid Kizim, Vladimir Solov'yev and Oleg At'kov are healthy and feeling well.

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ACADEMICIAN CHAZOV DISCUSSES BIOMEDICAL STUDIES ON 'SALYUT-7'

Moscow IZVESTIYA in Russian 24 Aug 84 p 2

[Article by A. Ivakhnov special correspondent at the Flight Control Center]

[Excerpt] The words "Period of communication in progress" shone on a screen over the entrance to the main room of the Flight Control Center. Seated next to the flight director at a control console in this room was academician Ye. I. Chazov, general director of the All-Union Cardiology Research Center. The scientist was talking with cosmonaut-researcher Oleg At'kov, who was preparing an experiment in space which is very important for science.

The academician answered journalists' questions during a break between periods of communication.

"What studies is O. At'kov conducting?"

"An experiment called 'Membrana' has been performed, for example. Experiments conducted earlier showed that in an organism, the content of calcium and several other elements on which the normal functioning of the heart depends decreases during prolonged flights. One of the parts of the cells of living organisms is the membrane, which is pierced by extremely fine channels. Microelements enter and leave the cell through these channels. Heart function thus depends on the condition of cell membranes. The main purpose of the 'Membrana' experiment is to ascertain how special substances which regulate calcium metabolism act on membranes. In the future, these substances may be used not only in space but also on Earth, for the prevention and treatment of certain illnesses.

"Right now, Oleg At'kov is conducting still another very interesting experiment, the 'Genom'. As you know, information which determines an organism's formation, development reactions to all kinds of stimuli is coded in the DNA molecule. Scientists are intrigued by the possibility of separating DNA into separate fractions and studying links of these living chains individually. In terrestrial conditions, this process is very much impeded by thermal convection, for example. The separation of DNA in space conditions was proposed. A unique instrument was developed, and everyone is now very excited by the way it is operating. But we will not know the results until O. At'kov and his comrades return to Earth."

"What are his functions as a space doctor?"

"He has plenty of other work in this area too. A set of instruments on board the orbiting complex enables him to perform extremely detailed studies of the condition of the cosmonauts' cardiovascular systems and of a whole series of other organs. Take, for example, the echocardiograph in whose development Oleg himself took part. Similar instruments which we have here at the center weight 50-60 kilograms. But the weight of the instrument designed for operation in space is 2.5 kilograms. "Very interesting are studies aimed at determining the optimum length of the working day in space. Crews now spend an enormous amount of time doing physical exercises. Physical exertion stimulates the functioning of internal organs and prevents muscles from growing unaccustomed to Earth's gravity. But what kind of exertion should this be, and would it be possible to increase it while simultaneously shortening the time spent on exercises? Any experiments for this purpose can be conducted only with the direct participation of a physician to carefully monitor the condition of all of the organs of the cosmonauts who are the test subjects."

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COSMONAUTS PASS 200 DAY MARK ON 'SALYUT-7'

Moscow PRAVDA in Russian 27 Aug 84 p 1

[TASS Report]

[Text] Flight Control Center, August 26. Following the completion of the program of joint flight, the automatic cargo ship "Progress-23" was separated from the manned complex "Salyut-7"--"Soyuz T-11" today at 8:13 p.m., Moscow time. The undocking and departure of the spaceship were monitored by the Flight Control Center and the crew.

During the joint flight, all planned operations were carried out in their entirety: unloading, refueling of the station's combined engine assembly, and pumping of drinking water. Two corrections of the orbiting complex's trajectory of movement were executed with the aid of the cargo ship's engine.

Leonid Kizim, Vladimir Solov'yev and Oleg At'kov have completed their 200th day of work on board the "Salyut-7" station.

Medical examinations and geophysical experiments were performed today in accordance with the program.

The reactions of the cosmonauts' cardiovascular systems to simulated hydrostatic pressure created with the aid of the "Chibis" vacuum suit were evaluated in the course of a medical examination.

In line with the program of research of the Earth's natural resources and study of the environment, the crew performed a series of observations and photography of individual regions of our country's territory, using hand-held cameras and spectrometers.

The onboard systems of the manned complex and the automatic transport spaceship are functioning normally. The cosmonauts are feeling well.

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TASS REPORTS DESTRUCTIVE REENTRY OF 'PROGRESS-23'

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 29 Aug 84 p 1

[TASS Report]

[Text] Flight Control Center, August 28. The flight of the automatic transport spaceship "Progress-23", which was launched into near-Earth orbit on August 14, 1984, has ended.

Today on commands from the Control Center, the ship was oriented in space, and its engine was fired at 5:28 a.m., Moscow time. As a result of braking, the "Progress-23" ship went into descending trajectory, entered the dense layers of the atmosphere, and ceased to exist.

Cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov are continuing planned work on board the manned scientific research complex "Salyut-7"--"Soyuz T-11". Scheduled for today are geophysical experiments, physical exercise and a televised report.

Another medical examination of the crew was conducted yesterday. The cosmonauts are healthy and are feeling well.

The research program in near-Earth orbit is being carried out successfully.

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TASS REPORTS 'BLACK SEA', 'GYUNESH' EXPERIMENTS

Moscow VECHERNYAYA MOSKVA in Russian 30 Aug 84 p 1

[TASS Report]

[Text] Flight Control Center, August 29. Leonid Kizim, Vladimir Solov'yev and Oleg At'kov are continuing to perform planned research and experiments on board the manned complex "Salyut-7"--"Soyuz T-11".

In line with the "Intercosmos" program of international cooperation in the field of the study and use of outer space for peaceful purposes, a comprehensive experiment, "Black Sea" and an aerospace experiment, "Gyunesh", were performed on August 28 and August 29, respectively.

Specialists of the People's Republic of Bulgaria, the German Democratic Republic, the Polish People's Republic and the Soviet Union took part in the preparation of the "Black Sea" experiment.

The "Black Sea" experiment is being conducted for the purpose of working out methodological problems of remote determination of characteristics of water surfaces. Individual regions of the Black Sea were photographed simultaneously from the "Salyut-7" station, the specialized oceanographic satellite "Cosmos-1500", laboratory airplanes and the scientific research ships "Mikhail Lomonosov" and "Professor Kolesnikov".

Data obtained in the course of this experiment will make it possible to optimize the operation of satellite systems for observing the ocean in the interests of the economies of countries taking part in the "Intercosmos" program.

Together with Soviet scientists, specialists of the People's Republic of Bulgaria, the Hungarian People's Republic, the German Democratic Republic, the Republic of Cuba, the Mongolian People's Republic, the Polish People's Republic and the Czechoslovak Socialist Republic took part in carrying out the "Gyunesh" experiment, which was performed in line with the program of an international space project called "Study of Geosystem Dynamics by Remote Methods".

Photography and spectrometry of the Earth's surface from the "Salyut-7" station were accompanied by simultaneous photographing from laboratory airplanes and mobile observation posts, which was performed with the aid of optical and radio-physical apparatus developed and manufactured in countries taking part in the "Intercosmos" program.

Results of this experiment will be used in the preparation of long-term forecasts in various branches of the economies of member-countries of the Council for Mutual Economic Aid. These results will also find use in the development of new equipment for remote sensing of the Earth.

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## COSMONAUTS PARTICIPATE IN MULTILEVEL REMOTE SENSING EXPERIMENT

Maku BAKINSKIY RABOCHIY in Russian 30 Aug 84 p 3

[Article by N. Barskiy correspondent]

[Text] In space, in the air and on the ground, an international experiment is being conducted for the study of natural resources by remote methods. On August 29, scientists and specialists of the USSR, Bulgaria, Hungary, the German Democratic Republic, Poland and Czechoslovakia began work at a scientific test range in the northwestern part of the Azerbaydzhan republic simultaneously with the crew of the "Salyut-7"--"Soyuz T-11" manned complex. The experiment is being conducted at the Azerbaijan Academy of Sciences' Institute for the Study of Natural Resources from Space--the coordinator of ground-based studies under the "Intercosmos" program.

While L. Kizim, V. Solov'yev and O. At'kov were conducting photography and spectrometry of the republic's territory from orbit, other participants in the experiment recorded the spectral characteristics of natural objects in the Sheki and Zakataly rayons and at the Mingechaur Reservoir. The aerospace experiment consisted of studies conducted at several levels, ranging from equipment in orbit and instruments on board airplanes and helicopters, to a ground-based automated information-and-measurement complex which was designed in Baku and had been used successfully before in the study of natural resources of the USSR, Bulgaria, Hungary and Czechoslovakia.

The scientific purpose of the project is the development and perfection of the scientific-methodological and physical-technical bases of environmental studies from space. Its applied aspect is to provide farmers with recommendations, maps and charts for the rational use of agricultural lands, pastures and reservoirs based on study of mountain-meadow, forest and valley geosystems. The materials obtained from the manned complex, correlated with data from aerial photography, ground-based observations and other studies conducted by scientists with equipment from member countries of the Council for Mutual Economic Aid, will make it possible to develop a unified methodology for the study of the Earth from space.

The Soviet and foreign participants of the international experiment are opening up another path for the peaceful utilization of space.

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## FURTHER DETAILS ON 'GYUNESH-84' EXPERIMENT

Baku VYSHKA in Russian 1 Sep 84 p 2

[Article by N. Barskiy special correspondent (Sheki)]

[Excerpt] Somewhere high above the clouds, the crew members of the "Salyut-7"--"Soyuz T-11" manned orbiting complex are keeping watch in space, while at the same time on the territory of Azerbaijan the participants of the international aerospace experiment "Gyunesh-84" are working with them.

Our "MI-8" helicopter, which for the experiment has been converted into a flying laboratory, is transporting a mixed crew of scientists and reporters from the Adzhinourskaya Steppe to the Alazan'-Agrichay Valley. A pasture near the village of Ashagy-Geynyuk in the Sheki Rayon has been transformed into a test range where scientists from different countries are perfecting methods of recording information from the space station and are testing equipment for measuring the temperature, moisture and other parameters of soils and the air and for the study of natural features.

Here, among the wildflowers, an observation station is set up on a heavy truck. This is where the information from AN-30 and AN-2 airplanes and from helicopters is received and is entered into the computer memory of the ground-based measuring-instrument complex. "Nika", as the scientists call the complex for short, has already functioned efficiently in Hungary, Poland and Czechoslovakia. Developed by specialists of the Azerbaijan Academy of Sciences' Institute for the Study of Natural Resources from Space, it has now become a mobile laboratory for the measurement, gathering, preliminary processing and transmission of data on environmental parameters.

At a press conference in Sheki, V. A. Lyakhov and L. I. Popov, pilot-cosmonauts of the USSR, gave high praise for the international experiment now under way on the territory of Azerbaijan.

(A photograph is given showing Popov and Lyakhov with two other participants in the experiment, N. A. Gulyiyev, vice-president of the Azerbaijan Academy of Sciences, and A. N. Shutko, USSR State Prize laureate.)

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'SALYUT-7' ONE OF SEVEN LEVELS IN 'GYUNESH-84' EXPERIMENT

Moscow IZVESTIYA in Russian 5 Sep 84 p 6

[Article by V. Arsen'yev and Sh. Medzhidov correspondents]

[Abstract] The article is a report from the Sheki-Zakatalinskiy Scientific Survey Range in Azerbaijan republic during the international aerospace experiment called "Gyunesh-84", in which features of land and bodies of water were examined with the aid of aerospace technology, including the orbiting station "Salyut-7". Various sites of the experiment and procedures employed are identified, and comments of some participating scientists are recorded. It is noted that the Sheki-Zakatalinskiy range covers an area 200 by 60 kilometers. It is said to be unique in that elevations from 100 to 3,500 meters are found here, and six of the planet's 12 climatic zones are represented on its territory, from the semi-arid zone to the mountain tundra. In addition to the space station, airplanes and helicopters carried instruments which recorded characteristics of the water and soil surface, including plant cover. The authors explain that measurements from different levels of the atmosphere help to make allowances for distortions caused by the atmosphere in photographs of the Earth's surface taken from space, and in this experiment there were seven such levels, with the "Salyut-7" station representing the uppermost one. At the bottom level was a variety of ground-based equipment, including a mobile laboratory called the NIKA, which is an acronym of the Russian words for 'ground-based automated comprehensive measurements.'

The article records comments of Doctor of Technical Sciences T. Ismailov, general director of the Azerbaijan Academy of Sciences' Research and Production Association for study of Natural Resources from Space, which coordinated all of the operations in the air and on the ground. He explained that the experiment's name "Gyunesh" means 'sun' in Azeri, and this was significant because the sun's rays reflecting off natural objects carries information that was recorded in the experiment by spectrometers, infrared radiometers and imagers, and other instruments.

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## SCIENTIFIC DIRECTOR ON RESULTS OF 'GYUNESH-84' EXPERIMENT

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 9 Sep 84 p 2

[Text] Sheki, Azerbaijan SSR. From heights beyond the clouds to the grain fields of Azerbaijan--such was the scope of the studies of the international aerospace experiment "Gyunesh" which has been completed at the Sheki-Zakataly Survey Range. The study of natural systems by methods of remote examination of the Earth was conducted under the "Intercosmos" program by scientists of the USSR, Bulgaria, Hungary, the German Democratic Republic, Poland and Czechoslovakia, with the participation of cosmonauts L. Kizim, V. Solov'yev and O. At'kov.

T. Ismailov, general director of the Azerbaijan Academy of Sciences' research and production association for space research and the scientific director of the experiment, commented on its results:

"In the course of the experiment, variants of performing ground-based and airborne studies coinciding with ones done on the manned orbiting complex were perfected. For this purpose, laboratory airplanes of the USSR Academy of Sciences' Institute of Radio Engineering and Electronics and of other scientific institutions were used, as well as a ground-based automated information-and-measurement complex designed in Baku, and equipment designed by scientists and specialists of member countries of the Council for Mutual Economic Aid.

"In addition to basic problems of perfecting methods for studying the environment from space, a number of tasks of economic importance were solved. In the course of the experiment maps were made of the distribution of mineral salts in Lake Adzhinour, which is in the northwest part of Azerbaijan. Specialists of the State Grain Farm imeni Ordzhonikidze, which is the republic's largest, received maps of soil moisture content in fields of their farm. Spectrometry of farm crops was done, and the biochemical composition of the water of the Mingechaur Reservoir was analyzed."

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## UKRAINIAN INSTITUTE'S ROLE IN SPACE ELECTROPHORESIS STUDIES

Kiev PRAVDA UKRAINY in Russian 2 Sep 84 p 2

[Article by V. Babskiy, Laboratory head, Ukrainian Academy of Sciences' Institute of Molecular Biology and Genetics, Ukrainian State Prize laureate]

[Abstract] The author comments on methods and purposes of electrophoresis experiments which cosmonauts have been conducting in the "Tavriya" unit on the orbiting station "Salyut-7". Ukrainian organizations which have had a role in the space electrophoresis research are identified. The Ukrainian Academy of Sciences' Institute of Molecular Biology and Genetics was one of the initiators of the work. Electrophoresis specialists of the Crimean Medical Institute were enlisted in it. These specialists were under the direction of G. V. Troitskiy, corresponding member of the Ukrainian Academy of Sciences. The author notes that the "Tavriya" unit was named in recognition of their services. Both institutes reportedly were involved in the latest series of experiments performed on board "Salyut-7".

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'SALYUT-7' COSMONAUTS COMPLETE 208 DAYS IN ORBIT

Moscow VECHERNYAYA MOSKVA in Russian 4 Sep 84 p 1

[TASS Report]

[Text] Flight Control Center, September 3. Leonid Kizim, Vladimir Solov'yev and Oleg At'kov have been working in near-Earth orbit for 208 days.

The cosmonauts have made the last photographs in line with the programs of the international aerospace experiments "Chernoye more" (Black Sea) and "Gyunesh". Photography and spectrometry of waters of the Black Sea and of the Sheki-Zakatal'skiy Scientific Test Range in the Azerbaijan SSR were conducted from the "Salyut-7" station and by subsatellite means of measurement equipped with instruments developed and manufactured in countries participating in the "Intercosmos" program.

The crew of the orbiting complex has begun a series of astrophysical studies of x-ray sources in the constellations Sagittarius and Cygnus, and in the Crab Nebula. Measurements are being made with apparatus delivered to the station by the "Progress-23" cargo ship.

In line with the plan of medical examinations, an experiment called "Sport" is being conducted today. Its purpose is to evaluate the effectiveness of various conditioning regimens on the health and physical working fitness of the cosmonauts in the course of prolonged orbital flight.

According to results of telemetry measurements and reports from orbit, the onboard systems of the manned scientific research complex "Salyut-7"--"Soyuz T-11" are functioning normally.

Cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov are healthy and are feeling well.

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TASS REPORTS 'SALYUT-7' COSMONAUTS SET NEW ENDURANCE RECORD

Moscow GUDOK in Russian 8 Sep 84 p 1

[TASS Report]

[Text] Flight Control Center, September 7. Cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov have been working in near-Earth orbit for 212 days. Today they surpassed the achievement of Anatoliy Berezovoy and Valentin Lebedev, who made an orbital mission lasting 211 days in 1982.

Astrophysical experiments are continuing on board the scientific research complex "Salyut-7"--"Soyuz T-11". The purpose of these experiments is to measure spectra of galactic and extragalactic sources of x-radiation in a wide range of energies, with the aid of the telescope-spectrometer "Siren'", which was developed jointly by specialists of the Soviet Union and France. The cosmonauts performed several cycles of studies of the Crab Nebula yesterday, and the constellation Cygnus has been selected as the object of observations today.

In the course of the day, the crew will perform a series of experiments in line with the program of research of the Earth's natural resources and study of the environment, and it is doing preventive work on individual systems of the station.

All of the crew's members underwent a comprehensive medical examination during the days just past. Reactions of their cardiovascular systems to simulated hydrostatic pressure created with the "Chibis" vacuum suit were evaluated, in particular. Physiological parameters were recorded with the multifunctional apparatus "Reograf", "Aelita" and "Ekhograf". According to results of medical monitoring and reports from orbit, Leonid Kizim, Vladimir Solov'yev and Oleg At'kov are maintaining high working fitness and a good state of health.

The longest manned flight in the history of cosmonautics is continuing successfully.

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MEDICAL DIRECTOR ON COSMONAUTS' PHYSICAL CONDITION AFTER 212 DAYS

Moscow SOVETSKAYA ROSSIYA in Russian 7 Sep 84 p 1

[Article by B. Gerasimov, correspondent at the Flight Control Center]

[Abstract] The article reports on activities of cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov as their mission on board the orbiting station "Salyut-7" was approaching a record duration of 212 days.

A. D. Yegorov, one of the directors of the medical program for the mission, is quoted in regard to the cosmonauts' health and physical condition. He reported that the cosmonauts had been weighed recently. It was found that one of them had gained 1.5 kilograms, while another was slightly thinner, and the weight of the third remained the same. Yegorov observed that these changes are of little consequence, and that medical support specialists are primarily interested in changes in muscular-tissue mass. Although some changes have been observed in this respect, they are within safe limits. Yegorov mentioned that the cosmonauts have been taking all the vitamins prescribed for them, but they have not touched their supply of medicines. None of the crew has suffered from influenza, acute respiratory illnesses or angina. Each crew member reportedly spends two hours a day doing physical exercise.

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'SALYUT-7' COSMONAUTS CONTINUE ASTROPHYSICAL, MEDICAL RESEARCH

Moscow IZVESTIYA in Russian 15 Sep 84 p 1

[TASS Report]

[Text] Flight Control Center, September 14. Leonid Kizim, Vladimir Solov'yev and Oleg At'kov are in their 220th day of work in near-Earth orbit.

Several series of astrophysical studies were carried out on board the manned complex "Salyut-7"--"Soyuz T-11" in the days just past. With the aid of the telescope-spectrometer "Siren'", which was built jointly by specialists of the Soviet Union and of France, measurements were made of spectra of x-ray sources of galactic and extragalactic origin and located in the constellations Sagittarius and Cygnus.

Today a large part of the time is reserved for medical examinations of the crew. In the morning an experiment was performed for the purpose of measuring the composition of micro-impurities in the station's air. Studies of acuity and depth of vision are planned. Cosmonaut-researchers Oleg At'kov will take samples of venous blood from the commander and the flight engineer, for in-depth analysis of features of the biochemical composition and of water-salt metabolism in the human organism which has been in zero-gravity for an extended period of time. Comprehensive studies will be performed for the purpose of evaluating the reaction of the cosmonauts' cardiovascular systems to simulated hydrostatic pressure created in the vacuum suit "Chibis".

In line with the program of geophysical experiments, the cosmonauts will carry out a cycle of observations and photography of separate regions of the world's oceans, using hand-held cameras and spectrometers. Also planned are experiments aimed at evaluating parameters of the atmosphere around the orbiting complex.

According to telemetry data and the crew's reports, the systems of the station are functioning normally. The cosmonauts are healthy and are feeling well.

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## 'SALYUT-7' COSMONAUTS WORK WITH RS-17 AND GSPS X-RAY TELESCOPES

Moscow PRAVDA in Russian 21 Sep 84 p 6

[Article by A. Pokrovskiy, special correspondent at the Flight Control Center]

[Excerpt] The "Mayaki" ["Soyuz T-10 commonauts] began installation work immediately after unloading the spaceship "Progress-23". It was not the first time that Leonid Kizim, Vladimir Solov'yev and Oleg At'kov had done duty as space installation workers. But this time they also had to prepare a working place for themselves, so that they could perform the role of astrophysicists. The reason was that "Progress-23" had delivered two x-ray telescopes to the station.

One of them, the RS-17, was built in Baku. This instrument is a result of cooperation between specialists of the USSR Academy of Sciences' Institute of Space Research and the Azerbaijan Academy of Sciences' Research and Production Association for Space Research. The other instrument, the GSPS (gas scintillation proportional spectrometer), is the latest arrival from France on board "Salyut-7". Thus was laid the technical foundation for the experiment called "Siren"--spectrometric research of x-ray sources.

Soon after the [Soviet-French manned] mission, Leonid Kizim and Vladimir Solov'yev, who were back-ups to the crew of Vladimir Dzhanibekov, Aleksandr Ivanchenkov and Jean-Loup Chretien, visited the Toulouse space center with the three crewmen. At that time J. C. Yousson, director of this center, praised highly this crew's work with the French instrument "Piramig", which is intended for photographing space objects. He added that he would like to receive more materials of this kind. Kizim and Solov'yev kept a modest silence then. They are now responding with deeds to the wishes of many scientists who are working in the field of x-ray astronomy.

'The 'Mayaki' are working very confidently,' related O. Prilutskiy and A. Melioranskiy, associates of the USSR Academy of Sciences' Institute of Space Research. "They have already completed 46 sessions, observing the most interesting x-ray sources, particularly in the Crab Nebula and the constellation Cygnus."

The two instruments complement one another. The CSPS has high resolving power, while the RS-17 receives so-called hard x-radiation, i.e., the photons which have the greatest energy in this range.

"Scientists now think that x-radiation accompanies the final stages of the evolution of certain stars, as well as processes which lead to the death of giant stars," commented R. Syunyayev, head of the department of high-energy astrophysics of the Institute of Space Research.

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## COMMENTS ON RS-17 X-RAY TELESCOPE

Baku VYSHKA in Russian 6 Oct 84 p 3

[Excerpt] As has already been reported, in the course of their 237-day mission, the longest in history, Leonid Kizim, Vladimir Solov'yev and Oleg At'kov worked synchronously with scientists of the USSR and countries of the socialist commonwealth while performing the space experiment "Gyunesh". It was conducted in the Sheki-Zakataly survey area of the Azerbaijan Academy of Sciences.

The participation of Azerbaijan scientists in the record near-Earth flight was not confined to this experiment, however. An original instrument, the x-ray telescope RS-17, was on board the "Salyut-7" station. This instrument was developed in creative collaboration by specialists of the USSR Academy of Sciences' Institute of Space Research and the Azerbaijan Academy of Sciences' Research and Production Association for Space Research, the first institute of its kind in the country. The RS-17 was manufactured in Baku.

E. Yu. Salayev, president of the republic Academy of Sciences, commented on this fact at the request of a correspondent:

"X-ray telescopes, particularly the RS-17, record radiation in an extremely wide range of energies--2,000 to 800,000 electron volts. These telescopes make it possible to observe black holes, x-ray pulsars and other objects, such as those in the constellation Cygnus and the Crab Nebula. Such studies are helpful primarily in gaining a knowledge of the history of the Earth's formation and development as a planet. But they are important also for obtaining data on the state of plasma and thermonuclear reactions in objects that are observed. This is necessary so that information which is amassed can be utilized in the future in the development of highly effective thermonuclear units, which will be so essential for solving the acute problem of the energy crisis in our life on Earth."

(A photograph is given showing senior project engineer Ali Aliyev and a technician working on the telescope.)

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TASS REPORTS COSMONAUT ACTIVITY FOR DAY 227 IN ORBIT

Moscow IZVESTIYA in Russian 22 Sep 84 p 1

[TASS Report]

[Text] Flight Control Center, September 21. The flight of the crew of the scientific research complex "Salyut-7"--"Soyuz T-11", the longest one in history of cosmonautics, is continuing. Leonid Kizim, Vladimir Solov'ye and Oleg At'kov are in their 227th day of work in outer space.

The program of astrophysical experiments using the x-ray telescope-spectrometer "Siren", which was developed by Soviet and French specialists, has been completed. In 46 sessions, measurements were made of spectra of x-ray sources of galactic and extragalactic origin in the constellations Sagittarius and Cygnus, and in the Crab Nebula.

The crew's work schedule today includes technical experiments, preventive maintenance measures with individual systems, replacement of assemblies and parts whose guaranteed service life is running out with new ones, taking inventory of equipment and instruments, and physical exercise on the exercise bike and running treadmill.

An experiment using an infrared radiometer will be conducted for the purpose of studying the temperature of various elements of the station by remote methods.

According to the crew's reports and telemetry data, the systems of the orbiting complex are functioning normally. The cosmonauts are feeling well.

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TASS REPORTS COSMONAUTS BEGINNING PREPARATIONS FOR RETURN

Moscow IZVESTIYA in Russian 26 Sep 84 p 6

[TASS Report]

[Text] Flight Control Center, September 25. The 33rd week of the orbital flight of Leonid Kizim, Vladimir Solov'yev and Oleg At'kov, the crew of the scientific research complex "Salyut-7"--"Soyuz T-11", is coming to an end.

Today the cosmonauts will conduct another medical examination: their pulses, arterial pressures and respiration rates will be measured, and electrocardiograms will be made.

Also planned are technical experiments for measuring characteristics of the atmosphere in the immediate vicinity of the orbiting complex. The crew will rest for a portion of the day. Daily physical exercises are receiving much attention over the course of the entire prolonged flight. For the purpose of preparing for the return to Earth, the cosmonauts began regular conditioning exercises using the "Chibis" vacuum suit during the days just past. Effects of terrestrial gravity are simulated by fluctuations of barometric pressure in this suit.

According to telemetry data and reports from orbit, the flight is proceeding normally. Leonid Kizim, Vladimir Solov'yev and Oleg At'kov are feeling well.

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COSMONAUTS IN DAY 234, PREPARING FOR DESCENT

Baku BAKINSKIY RABOCHIY in Russian 29 Sep 84 p 1

[TASS Report]

[Text] Flight Control Center, September 28. Leonid Kizim, Vladimir Solov'yev and Oleg At'kov have been working in near-Earth orbit for 234 days.

In accordance with the flight program, the cosmonauts are completing research and experiments on board the manned complex "Salyut-7"--"Soyuz T-11" and are preparing the station for flight in the automatic mode.

The crew will perform comprehensive medical examinations today. Studies of the bioelectric activity of the heart are planned, in particular. Physiological parameters will be recorded with the aid of the multifunctional apparatus "Aelita".

During the days immediately ahead, the crew is to reactivate scientific apparatus, units and onboard systems of the station and transfer containers with materials from studies that have been completed to the reentry vehicle of the "Soyuz T-11" spaceship.

According to results of medical monitoring and reports from orbit, the condition of all the cosmonauts' health is good and they are feeling well. The commander's pulse rate is 68 beats per minute, the flight engineer's is 66 beats per minute, and the cosmonaut-researcher's is 63 beats per minute. Their arterial pressures are 120 over 65, 115 over 60, and 120 over 70 millimeters of mercury, respectively.

The flight of the manned complex "Salyut-7"--"Soyuz T-11" is proceeding normally.

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COSMONAUTS CONTINUE PREPARATIONS FOR RETURN

Moscow VECHERNYAYA MOSKVA in Russian 1 Oct 84 p 1

[TASS Report]

[Text] Flight Control Center, October 1. The longest space flight in history is nearing completion. Soviet cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov have carried out all of their program of scientific research on board the "Salyut-7" station and will return to Earth tomorrow.

Today the crew is checking the operational fitness of onboard systems of the "Soyuz T-11" spaceship, transferring materials from research and experiments to the spaceship's reentry vehicle and stowing them there, and putting used-up equipment in the spaceship's living compartment. The cosmonauts are performing planned operations for deactivating scientific apparatus and individual units of the station, and they are taking samples of air and microflora inside the complex for subsequent laboratory analysis. In the course of the day, they will also engage in physical exercises, as well as conditioning exercises using the "Chibis" vacuum suit.

According to results of telemetry measurements and the crew's reports, the flight of the orbiting scientific research complex "Salyut-7"--"Soyuz T-11" is proceeding normally.

The condition of the health of Leonid Kizim, Vladimir Solov'yev and Oleg At'kov is good, and they are feeling well.

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'SALYUT-7' COSMONAUTS RETURN TO EARTH 2 OCTOBER

Moscow KOMMUNIST in Russian 3 Oct 84 p 1

[TASS Report]

[Excerpt] Following the completion of their program of scientific and technical research and experiments on board the orbiting complex "Salyut-7"--"Soyuz T-11", cosmonauts Leonid Denisovich Kizim, Vladimir Alekseyevich Solov'yev and Oleg Yur'yevich At'kov returned to Earth on October 2, 1984, at 1:57 p.m., Moscow time. The "Salyut-7" station, which was placed into near-Earth orbit on April 19, 1982, is continuing its flight in the automatic mode.

The reentry vehicle of the "Soyuz T-11" spaceship landed 145 kilometers southeast of the city of Dzhezkazgan.

A medical examination performed at the landing site indicated that the cosmonauts withstood the prolonged stay in conditions of weightlessness well.

A large amount of scientific-technical and medical-biological research and experiments was performed in the course of the 237-day flight of the primary crew of the "Salyut-7" station.

Results of research and experiments which were obtained during the 237-day flight will find broad application in various branches of science and the economy, and will also be used in the development of permanently operating orbiting complexes.

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## 'SALYUT-7' COSMONAUTS' POST-FLIGHT CONDITION

Moscow MEDITSINSKAYA GAZETA in Russian 5 Oct 84 p 3

[Article by V. Pishchik, correspondent]

[Abstract] The article reports on results of the recently completed 237-day mission of cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov on the orbiting station "Salyut-7". Some of the cosmonauts' postflight activities at the Baykonur Cosmodrome are mentioned. During the first three days of their period of readaptation, they were following a program which included hydrotherapeutic procedures, massage and a gradual increase in motor activity, including walks outdoors.

Doctor of Medical Sciences Yevgeniy Borisovich Shul'zhenko, member of the board of the USSR Ministry of Public Health and one of the directors of medical support for the mission, is quoted in regard to the nature and results of the medical-biological studies and experiments which the cosmonauts performed. The main result, according to Shul'zhenko, was the fact that the crew remained in good health and maintained the necessary level of working fitness and excellent morale throughout their prolonged mission. He mentioned that the initial medical examinations of the crew performed at the landing site and the cosmodrome indicated that the cosmonauts had no bad effects from the re-encounter with terrestrial gravity.

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**FEOKTISTOV COMMENTS ON 'SALYUT-7' FUEL LINE REPAIR**

**Moscow PRAVDA in Russian 3 Oct 84 p 3**

**[Article by V. Zubarev]**

**[Abstract]** The lengthy article recalls highlights of the 237-day mission of cosmonauts Leonid Kizim, Vladimir Solov'yev and Oleg At'kov on the orbiting station "Salyut-7". Comments made by the cosmonauts during a press conference by radio before leaving the station are recorded.

Also recorded are comments of Professor K. P. Feoktistov, who spoke about the extravehicular activity of the crew to repair a fuel line on the station. He related: "It was necessary to install bypass lines in the station's combined engine assembly. We prefer to fly free of doubts about our equipment. On the ground we checked out all variants. It became clear: the work could be done, but it would require several walks into open space. At the same time, the most unlikely variant appeared to be one which would require six walks by the cosmonauts. I'll be honest and admit that I thought we could do it with fewer. But it turned out that it was precisely this variant that was necessary. In short order we made a special tool for clamping the pipeline, and we trained the crew of the visiting expedition in the practice pool. Then Vladimir Dzhanibekov familiarized the 'Beacons' (primary crew) with the new procedures. Leonid Kizim and Vladimir Solov'yev performed the complex operations in orbit brilliantly. Their experience undoubtedly has enriched manned space flight."

Recalling other events that occurred during the mission, the article mentions that Kizim's wife gave birth to a daughter in May.

It is also noted that the total number of experiments that the cosmonauts performed was close to 100, and the majority of them were performed several times. About 800 scientific and other organizations are said to have benefited from the results of the mission.

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SPACE SCIENCES

'ASTRON' TELESCOPE STABILIZATION SYSTEM

Moscow KOMMUNIST in Russian 15 Aug 84 p 2

[Article by G. Tovmasyan, Doctor of Physical-Mathematical Sciences, deputy director of the Armenian Academy of Sciences' Byurakan Astrophysical Observatory]

[Abstract] The author reports on the progress of the flight of the automatic space telescope "Astron", which was placed into orbit on March 23, 1983, and he mentions some of the features of equipment carried by this spacecraft. He relates that spectra with high resolution and other valuable astrophysical data are still being obtained with the aid of the "Astron", although it was designed to operate for only one year. The space telescope's components include a mirror 80 centimeters in diameter, a spectrometer which was built at the Marseilles Space Astronomy Laboratory in France, and an original system for stabilizing the aiming of the telescope at objects under study. This system was developed and built by scientists and specialists of the Armenian republic.

The author explains that such a system is necessary because the spectrometer's diaphragm, in which the image of an object to be observed must be captured and held, is only 40 micrometers in diameter. The telescope must therefore be aimed at this object with a permissible deviation of only a few tenths of a second of arc. The stabilization system has two operating modes. In the first of these, a portion of the light received from the object under study is used to control the system; consequently, only objects which are fairly bright can be recorded in this mode. The photographing of objects that are several thousands of times fainter is said to be possible in the system's second mode, which is called an offset guiding mode. In this case, the telescope is kept in the prescribed position by means of signals from a relatively bright star which is located near the object under observation.

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CSO: 1866/25

## RESULTS FROM 'ASTRON' ORBITING TELESCOPE

Frunze SOVETSKAYA KIRGIZIYA in Russian 20 Sep 84 p 2

[Excerpt] Simferopol' and Yerevan. The automatic observatory "Astron" has been operating successfully for a year and a half in an orbit with a high apogee. The largest orbiting telescope and a counter for recording x-radiation are installed on this spacecraft.

A TASS correspondent asked scientific directors of this program to comment on its results:

"Hundreds of periods of communications with the station have been conducted since the beginning of the experiment," said A. Boyarchuk, corresponding member of the USSR Academy of Sciences. "Here, for example, is a telemetry tape which was received recently from the 'Astron', following studies of the constellation Andromeda. It was discovered that one of its stars has a companion with a temperature of 60,000 degrees. This star's dimensions are small; its radius is less than the Earth's. This means that we are apparently dealing with a white dwarf."

Our knowledge of the universe's chemistry has expanded, thanks to the "Astron". Our information regarding the abundance of individual elements is extensive enough insofar as light elements are concerned, but information regarding heavy ones is far from complete. On the basis of reports received from the "Astron", academician A. Severnyy discovered tremendous surpluses (hundreds and thousands of times) of lead, tungsten, uranium and thorium in the atmospheres of a number of so-called peculiar stars.

"The automatic station 'Astron' has observed more than 20 galaxies with its keen eye," reported G. Tovmasyan, deputy director of the Byurakan Observatory. "A number of objects which have received no particular attention from astrophysicists up until now have been found to possess powerful ultraviolet radiation. They turned out to be galaxies in the constellations Virgo and Leo."

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**YAKUTSK INSTITUTE FOR COSMIC AND GEOPHYSICAL RESEARCH**

**MOSCOW IZVESTIYA IN RUSSIAN LANGUAGE**

[Article by B. Kondratenko, Moscow Bureau]

**[Abstract]** The article reports on the work and facilities of the Institute of Cosmic Physics Research and Aeronomy of the Yakutsk Affiliate of the Siberian Branch of the USSR Academy of Sciences. Prof. Yuriy Georgievich Shafer, age 75, has been the director of the institute since it was founded in 1962 on the basis of the Trans-Siberian Geophysical Observatory.

The institute operates a complex of geophysical observatories and stations, test ranges and other facilities spread over a vast territory of the Yakut Autonomous Republic. South to north, they extend from 61 to 76 degrees North latitude. The institute also has instruments operating on satellites. This complex is used for studies of the Ionosphere, magnetic fields and earth currents, cosmic rays and radio emissions, polar aurora and meteorological phenomena.

The article focuses on a large installation of the institute for investigating cosmic-ray showers. Called "SHAL", an acronym of the Russian words for 'broad cosmic-ray showers,' the installation has 75 main recording towers and interconnecting utility lines that together cover an area of 18 square kilometers in the vicinity of Yakutsk. It is one of the largest of four such facilities in the world. It is said that in more than 10 years of observations with this installation, a great deal has been learned about high-energy cosmic rays. Two scientists who have conducted research at the laboratories of the "SHAL", have received a Lenin Prize. It is mentioned that the "SHAL" is being developed.

The article also reports that the institute is planning the creation of a unique complex for study of the ionosphere. To be called the "Yakutskiy meridian", it will interconnect existing ionospheric stations near Yakutsk and in Zhigansk, a geospace-physics observatory in Siberia, and a station which is to be created on Kamchatka. It will be possible to discern from data received at a central post how the solar wind is flowing

around the Earth and what changes are being produced in the ionosphere. With this giant 'instrument' some 2,000 kilometers long, the institute's personnel propose that it will be possible to assess the radiation situation around the planet and to give accurate forecasts of shortwave radio conditions.

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## RADIO TELESCOPE WITH 256 ANTENNAS BUILT IN SIBERIA

Leningrad LENINGRADSKAYA PRAVDA in Russian 7 Oct 84 p 3

[Text] The building of a unique installation--a solar radio telescope--has been completed in the remote Badary area of the taiga, 250 kilometers southwest of Irkutsk.

Scientists are beginning their pursuit of the sun with the aid of this installation. The radio telescope is arranged in the form of a gigantic cross: 128 dish antennas lengthwise and the same number crosswise to form the cross' two beams--a 'north-south' and an 'east-west' one. Each beam is more than 500 meters long. Objects of study that are only 20 seconds of arc in size can be distinguished in radio representations of the sun that are obtained with the aid of this multiple-element radio telescope. One of the scientists' tasks is to study the structure and spread of the radio-frequency radiation of active regions and of flares on the sun. The new telescope will make it possible to obtain a two-dimensional, complete radio representation of the sun every three or four minutes, in the centimeter wave band.

The 'east-west' antennas are already yielding interesting information for the scientists. The adjustment of the second beam, the 'north-south' one, is nearing completion, after which the whole telescope will go into operation.

PTD/SNAP  
CSO: 1866/25

## 'ASTRON' X-RAY EXPERIMENT

Moscow ZEMLYA I VSELENNAYA in Russian No 2, Mar-Apr 84 pp 26-34

[Article by Doctor of Physicomathematic Sciences V. G. Kurt and Candidate of Physicomathematic Sciences Ye. K. Sheffer: "The Astron X-Ray Experiment"]

[Text] On 23 March 1983, the Soviet earth satellite Astron specially designed for astronomical observations was put into a high-apogee orbit. This article describes the preliminary results of the work done by the x-ray telescope spectrometer mounted on the satellite.

Until recently, extraatmospheric astronomical research in our nation was carried out from the Salyut stations and the Soyuz spacecraft on Prognoz automatic stations, by the earth satellites of the Cosmos series, by vertical geophysical rockets and by interplanetary stations launched toward the moon, Venus or Mars. Space solar observatories were employed for studying the sun. However, the study of stars and x-ray sources by telescopes of sufficiently large size is possible only from specialized astronomical satellites equipped with a highly accurate astroorientation and stabilization system. At present Soviet science has acquired such an instrument! Need it be said that hopes have been put on this launch and how much effort and material have been spent on developing the Astron satellite.

The aim of launching Astron is to study the stars and galaxies in the ultra-violet band of wave lengths (shorter than 3,000 Å) and to observe discrete x-ray sources. For carrying out these tasks the satellite carried an ultra-violet telescope of the Crimean Astrophysical Observatory of the USSR Academy of Sciences and a SKR-02M x-ray telescope spectrometer developed at the Space Research Institute of the USSR Academy of Sciences with the active collaboration of the State Astronomical Institute imeni P. K. Shternberg. The device was manufactured and developed at several industrial institutes and design bureaus under different ministries.

The preparation of the experiment and its successful execution took a total of 3 years. It was possible to develop such a complex and heavy satellite in a short period of time solely due to a major decision to use the Venera AMS [automatic interplanetary station] as the base device. From the station of the Venera series, Astron inherited many working systems: the astroorientation

assemblies, the power and temperature control system, the telemetry system and the radio command line.

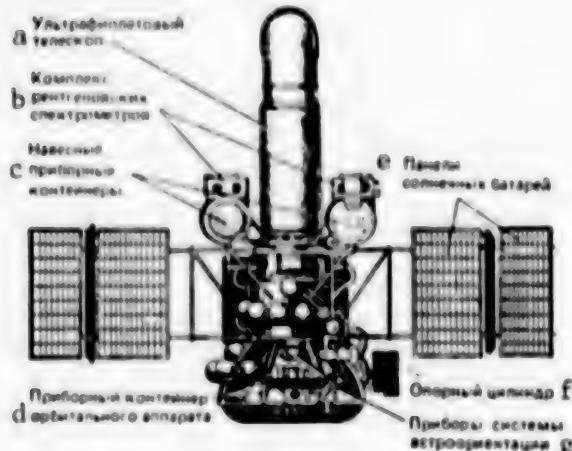


Diagram of Basic Units  
of the Astron Station

- Key:
- a--Ultraviolet telescope
  - b--Set of x-ray spectrometers
  - c--Mounted instrument container
  - d--Instrument container of orbital device
  - e--Solar battery panels
  - f--Support cylinder
  - g--Astroorientation system instruments

to alter two angular coordinates. Since the sun moves by  $1^{\circ}$  per day, the amount of the three angles of the orientation system depends upon the time of observations and is calculated ahead of time for the studied astronomical objects for the designated day and hour.

Among the navigation stars are more than ten of the brightest of which the most "convenient" is Canopus ( $\alpha$  Carinae). This star is close to the southern ecliptic pole and due to this it is always sufficiently distant from the sun (not closer than  $75^{\circ}$ ). Canopus is the sole navigational bright star which can be "used" year-round. The others are used as navigational ones only for a limited period of time: Vega ( $\alpha$  Lyrae) from January through June and August through December; Sirius ( $\alpha$  Canis Majoris) from March through May and September through November; Arcturus ( $\alpha$  Boötis) from December through February and from June through August and so forth. In principle any bright stars of both hemispheres of the heaven can be navigational stars.

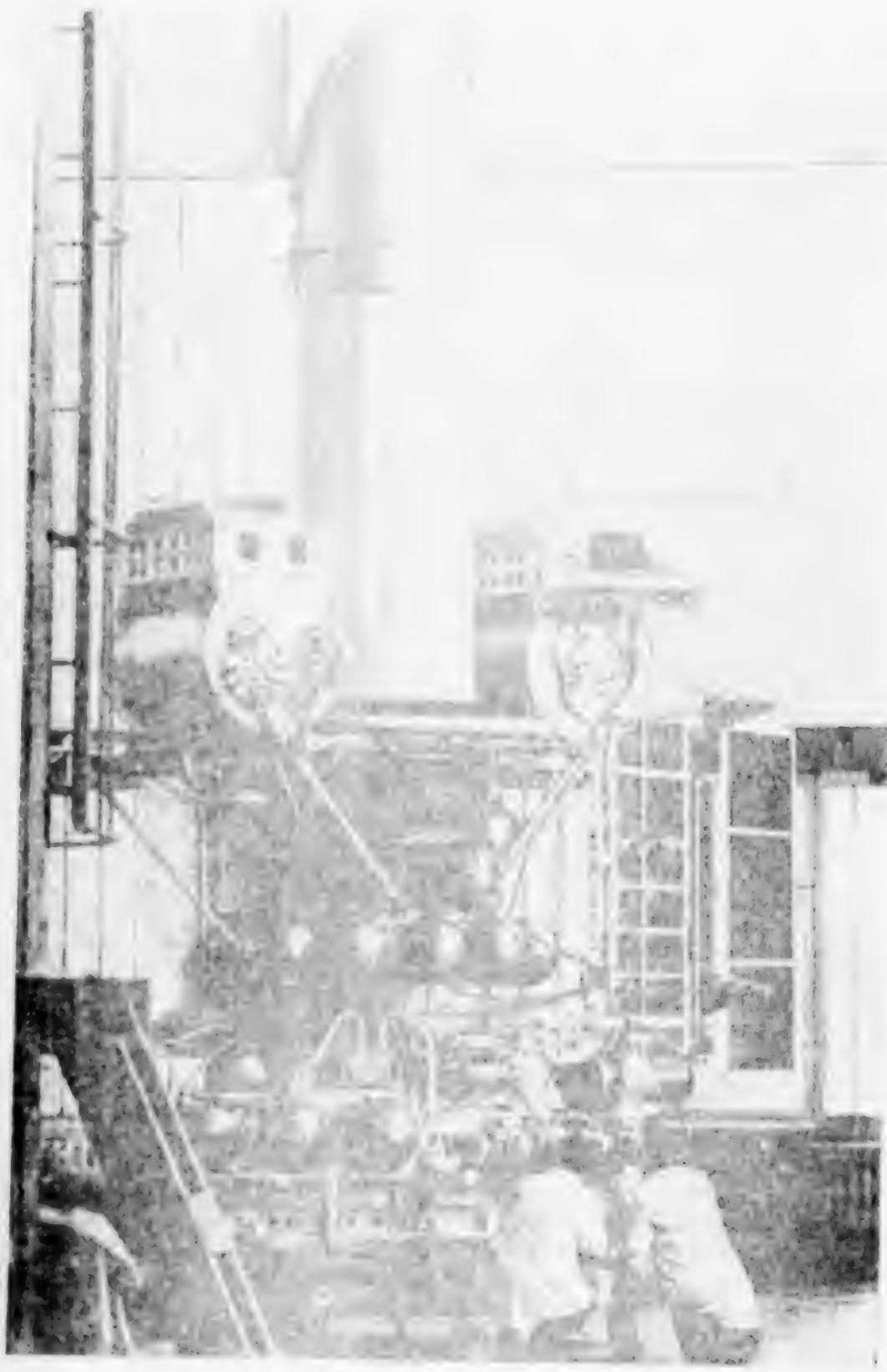
In order to locate the selected navigational star, the satellite slowly rotates around the axis aimed at the sun until the astral sensor "locks on" the star. All the information about it--its coordinates and brightness--are transmitted to the station in the form of coded digital radio commands. After "locking on"

## Orientation

The Astron station can function autonomously for a long time in orbit far from the earth. It has been adapted for extended (up to 5 hours daily) observation of x-ray and ultraviolet sources. The heart of the station is the solar-astro astro-orientation system making it possible to aim the ultraviolet or x-ray telescopes at the studied object. The triple-axis orientation of the station in space is provided by two sensors: a solar one which "looks at" the sun and an astro one aimed at a bright navigational star.

The scan zone of the solar sensor lies in a plane which passes through the optical axis of the scientific instruments. The sensor is aimed at the sun by changing one angle. The scan zone of the astral sensor is conical with an apex angle of  $\pm 25^{\circ}$ . The cone's axis is perpendicular to the optical axis of the scientific instruments.

In order to aim the astral sensor at the navigational star, it is essential



— 1960 — 1961 — 1962 — 1963 — 1964 — 1965 —

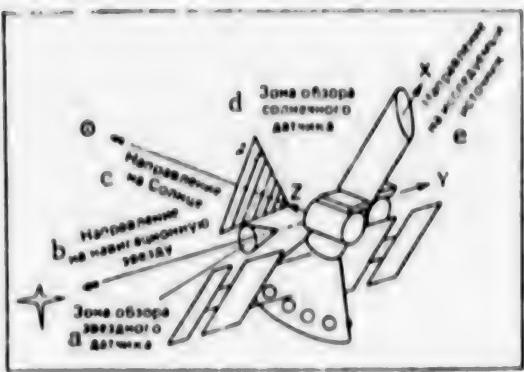


Diagram for Aiming the Astron Satellite at the Studied Object

The optical axis of the x-ray telescope-spectrometer parallel to the X axis is oriented in the set direction by aiming the solar sensor at the sun and the astro sensor at the chosen navigational star.

**Key:**

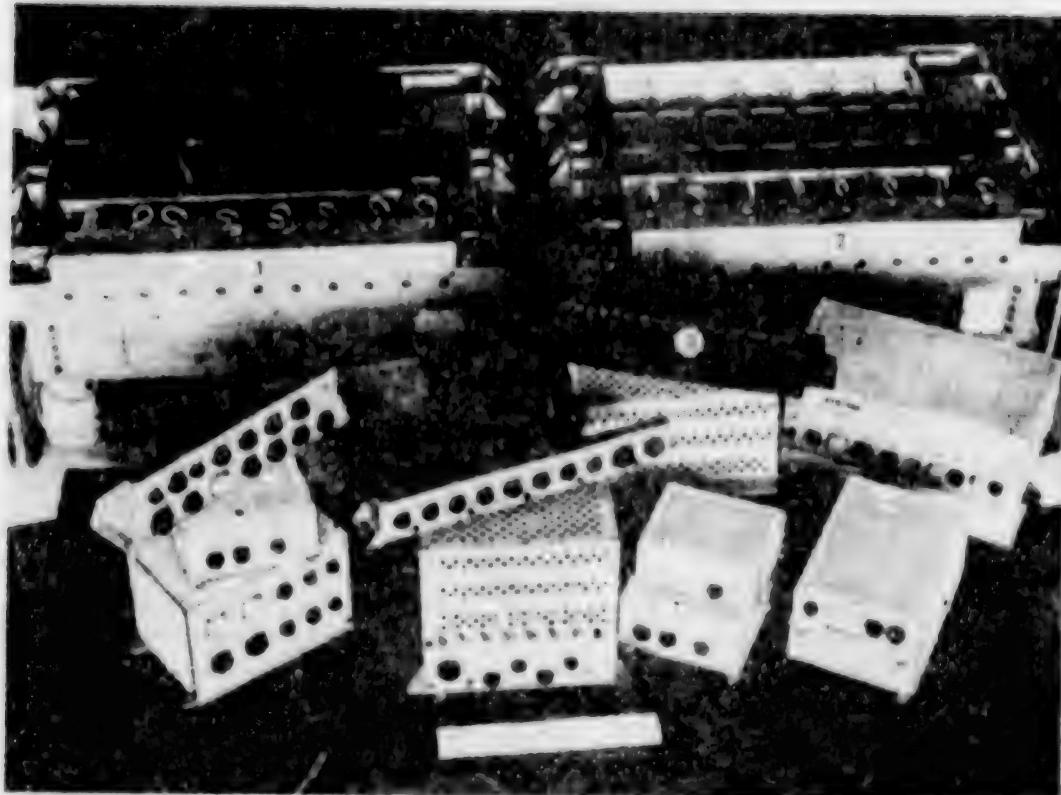
- a--Scan zone of astral sensor
- b--Direction to navigational star
- c--Direction to sun
- d--Scan zone of solar sensor
- e--Direction to studied source

the star, the satellite is stabilized in such a manner that the telescope's axis is looking at the designated x-ray source. The astroorientation system provides an accuracy of station guidance and stabilization on the order of several angular minutes and this is completely sufficient for x-ray observations.

The astral sensor is a very sensitive device and it "shuns" light from the sun, earth and moon. The angular distances to these heavenly bodies are calculated ahead of time and an observation session is carried out only in the instance that they are sufficiently remote from the navigational star. The high-apogee orbit with a maximum distance of around 200,000 km from the earth was chosen for the station because at its apogee the earth has a small angular dimension (a diameter of around  $3.5^\circ$ ). In low orbits the 150-degree disc of the earth frequently blocks out the navigational stars and in addition the danger of cluttering the astral sensor is great.

The x-ray telescope operates in a direct transmission mode as there is continuous two-way communications with the satellite without recording the information on board. During an observation session specialists monitor the work of all the systems of the spacecraft and the scientific equipment and above all the astroorientation system. Thus, observations on the x-ray telescope are carried out almost in the same manner as with a ground optical or radio telescope. In the course of the observations it is always possible to take a new decision and immediately carry it out and this is particularly important with unplanned situations related to problems in the equipment or the unexpected phenomena in the studied x-ray source. With the rise of such a situation it is possible to extend the session, to switch the scientific equipment to another mode or, conversely, shut down the entire instrument or a part of it. Once during observations there was a powerful solar flare and this led to a sharp rise in the background of solar-origin charged particles. All the scientific equipment had to be shut down immediately.

At the ground tracking station all the information received from Astron is displayed on television-type video displays, it is recorded in a graphic analog form on paper tape and is also fed into printers in a digital form. All of this helps not only to track but also effectively intervene in the observation sessions. Usually a session lasts 3-4 hours during which the x-ray telescope observes, as a rule, one source.



The SKR-02M X-Ray Telescope-Spectrometer:  
1, 2--Detectors (on one of them, the protective cover has been removed);  
3--Proportional counter. In the foreground are the electronic units  
of the spectrometer.

When necessary, the astroorientation system makes it possible to also carry out scanning of the skies, when the station rotates around the axis directed at the sun. In this instance, the axis of the x-ray telescope describes a circle in a celestial sphere with a center at the sun or at the "antisun," and here the radius of the circle can be altered so as to view selected areas of the sky. The period of one rotation equals approximately 12 minutes and this corresponds to an angular scanning velocity of  $0.5^\circ$  per second. Obviously, in a scanning mode there is less time for accumulating information and for this reason the sensitivity of the x-ray telescope is less than with extended aiming at the same source. Incidentally, repeated scanning of the same area of the sky can increase the threshold of detecting weak sources.

## The X-Ray Telescope-Spectrometer

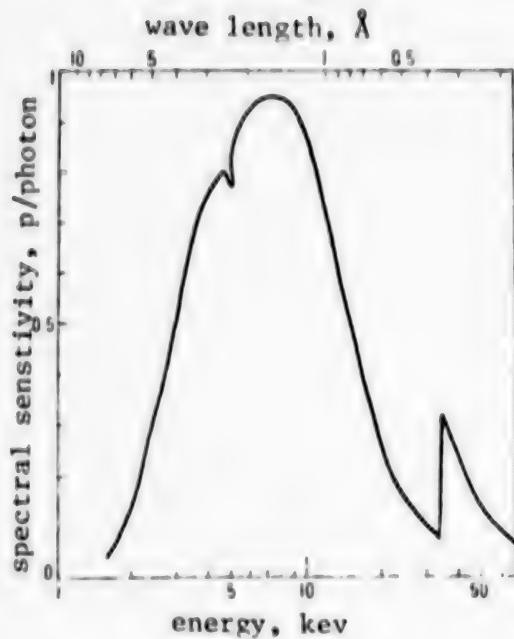
The x-ray telescope-spectrometer carried on Astron consists of two equal detecting units and over a score electronic units which record and process the information, transmit it to the telemetric system, control the work of the spectrometer and carry out its calibrating during the flight.

The detectors of the x-ray telescope are proportional gas-filled counters with a window of thin (around 100 microns) beryllium foil (ZEMLYA I VSELENNAYA, 1970, No 6, p 24.--Editors). Only beryllium foil with a thickness of 0.1-0.2 mm passes soft x-ray radiation. The size of the x-ray counter is 6x6x30 cm. Its housing is welded from titanium, a light and strong metal. The hermetic volume of the counter is filled with a heavy inert gas, xenon, with a pressure of around 0.25 atmosphere. Along the long axis of the counter is stretched a tungsten filament 0.05 mm thick. To the anode filament is applied a high positive voltage (2,000 volts), while the negative of the high-voltage source is connected to the titanium housing. When an x-ray quantum or a charged particle of energy (an electron, proton or meson) passes through the gas space of the counter, inside the counter, a cloud of ionized xenon atoms (ions) and electrons occurs. Due to the high potential of the anode filament, the formed electrons with a number of around 30 are accelerated in the electric field. In colliding with the xenon atoms which fill the counter, they increase the number of electrons and ions. The ions recombine on the methane or carbon monoxide molecules which are found in very small quantities (around 5 percent) in the counter's volume. The electrons formed strike the filament and this leads to the appearance of a brief electric pulse. Its amplitude is proportional to the energy of the absorbed x-ray quantum and this makes it possible to measure the energy spectrum of X-radiation striking the beryllium entry window of the counter. As a total the spectrometer has 14 working counters with an overall geometric area of around 2,000 cm<sup>2</sup>.

Unfortunately, the counters record not only the quanta of X-radiation but also the charged particles of cosmic rays of galactic and solar origin. The high-apogee orbit has freed the equipment of Astron from the influence of the earth's radiation belts which are full of high-energy particles (electrons and protons). At the same time, the Astron equipment is not protected by the earth's magnetic field against the soft component of cosmic rays.

In order to reduce the influence of the charged particles on the readings of the x-ray telescope, all the counters have been put in a box made from a plastic scintillator (a transparent sheet like organic glass) which effectively records charged particles. In striking the scintillator such a particle causes a burst of light which is recorded by four photoelectron multipliers. The signal from these multipliers blocks the simultaneous pulse from the counter, preventing it from reaching the record circuit. In addition, a scheme is used for analyzing the shape of the leading edge of the pulse which depends upon the type of ionizing radiation. The charged particles produce a longer build-up edge than do the x-ray photons.

The detector units also are equipped with an automatic gain control system. For this the eighth counter in each detection unit is constantly illuminated by



Curve of Spectral Sensitivity  
of X-Ray Telescope-Spectrometer  
Range of instrument's sensitivity  
from 2 to 25 kev.

the source spectrum. For example, among the spectrum parameters are the temperature of the x-ray source if its radiation is thermal and the number of absorbing hydrogen atoms on the path between the source and the recording instrument. Due to this absorption, intensity in the "soft" low-energy channels is reduced. Finally, the instrument makes it possible to record a change in the source's intensity within a broad range of frequencies: from 400 to hundredths and thousandths of a hertz. Periods from 0.002 to 1,000 seconds correspond to these frequencies.

The field of vision of the detectors is limited by a mechanical collimator of hexagonal shape. The angular dimension of the field of vision is  $3^\circ$  in projection on the celestial sphere. A change in the position of the source by  $2'$  causes a 1-percent change in the flux. This also sets the required accuracy of guidance and stabilization around  $2\text{-}3'$  and this is provided by the station's astroorientation system.

For periodic monitoring of all the equipment's parameters, at the end of a session the instrument can be calibrated upon a radio command. An isotope of radioactive iron is put in the field of vision of each counter. The position of the peak of the iron (a wave length of  $2 \text{ \AA}$ ) and the intensity of this line make it possible to monitor just how constant are the spectrometric properties of the equipment and if the graduating of the energy scale has changed then a correction is made in processing the data.

monochromatic X-radiation with a wave length of around  $2 \text{ \AA}$  which is produced by the radioactive isotope of iron. The position of the monochromatic line is stabilized by adjusting the high voltage which powers all the counters. This ensures the stability of the instrument's spectral sensitivity, in compensating for the temperature deviation of the counter's parameters.

The spectral sensitivity of the counter is determined by the passage of beryllium from the low energy side (longer wave lengths) and by the effective absorption of the X-radiation by the xenon on the high energy side (shorter wave lengths). The sensitivity range of the instrument is 2-25 kev in an energy scale or  $0.5\text{-}6 \text{ \AA}$  on a wave length scale. The entire range has been divided into ten approximately equal intervals and this ensures the obtaining of the source's spectrum. In adjusting the spectrum parameters on the computer to the observed ten values (according to the number of channels) of intensities, it is possible to recreate

The weight of the x-ray telescope-spectrometer is around 250 kg of which more than 90 percent goes to the detection units. Particularly heavy are the massive plates of the plastic scintillator with an area of around  $1 \text{ m}^2$  each and the collimators placed in front of each of the four counters.

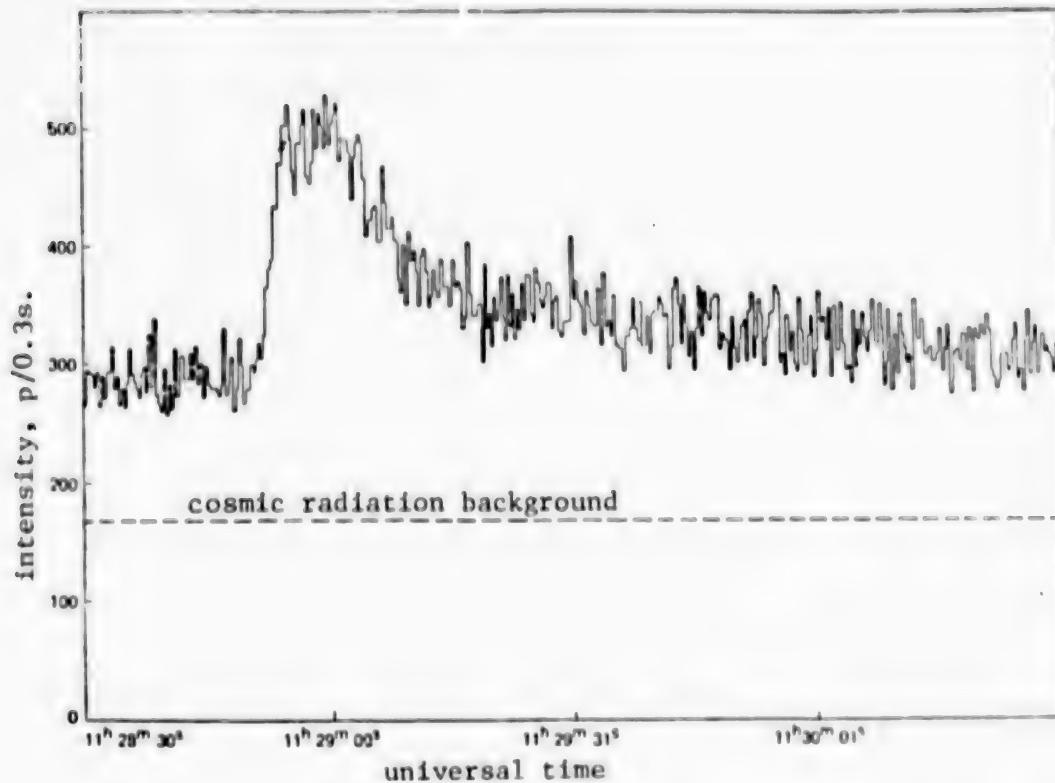
### The First Observation Results

A week after the launching of the Astron satellite into orbit, a brief test session was run during which the detection units and all the systems of the x-ray spectrometer were turned on in sequence. Naturally here the axis of the spectrometer was aimed at an "empty spot," that is, at a point where there were no sources of X-radiation. After the test session an optimum operating mode was chosen for the instrument, the background level of charged particles was assessed and we were able to clarify how the equipment functioned in sending the basic commands for controlling the x-ray spectrometer.

For all the participants in the experiment, this session was the most crucial and everyone was in the main room of the mission control center and each was sitting in front of his display, work station or command post. The control commands for the spectrometer were given at a slow pace and after each of these commands for several minutes the participants in the experiment analyzed the telemetric data shown on the displays, informing the flight control of the results of the analysis over the loudspeaker system. Then there was an alignment session. During this session which lasted around an hour, we determined the parallelness of the axes of the x-ray telescope-spectrometer and the station's astroorientation system. The spectrometer was aimed at a very bright x-ray source in the constellation of Taurus, the famous Crab Nebula. This was chosen as a calibrating source for several reasons: in practical terms this is a point object, its spectrum has been well studied, the source is very stable and does not change over time and in its radiation there is a 10-percent pulsating component, the radiation of the pulsar NP 0532 with a period of  $0.33'$ . Four times the axis of the x-ray telescope was aimed at the Nebula and shifted from it to points distant by  $6^\circ$ . The telescope's field of vision as it were "drew" in the sky a cross with an angular dimension of  $12^\circ$ . The obtained data made it possible to lay out a program for calculating the spectrum of the sources and determine the effective area of the instrument which was  $1,700 \text{ cm}^2$ . We also tested out the channel for recording the highly variable radiation of pulsar NP 0532. After the alignment session the planned observations of the x-ray sources started.

Particular attention was given to the rapidly changing forces, to flaring sources (bursters) and nonstationary x-ray stars such as Cygnus X-1, Cygnus X-3, Ophiuchus X-2, to the star RU of Lupus. Of the extragalactic objects we observed the quasar 3C 273, the gigantic elliptical galaxy NGC 4486 in the constellation of Virginis, the peculiar galaxy NGC 7552 in the constellation Grus, the supernova which had flared up in the spiral galaxy M 83 in the constellation Hydra, the popular object SS 433 and a number of other objects.

During the session of 30 June 1983, against expectations, a signal was not received from the bright and well-studied source Hercules X-1, a binary system the optical component of which is the variable star HZ of Hercules and the x-ray is the neutron star (ZEMLYA I VSELENNAYA, 1975, No 5, p 34.--Editors).

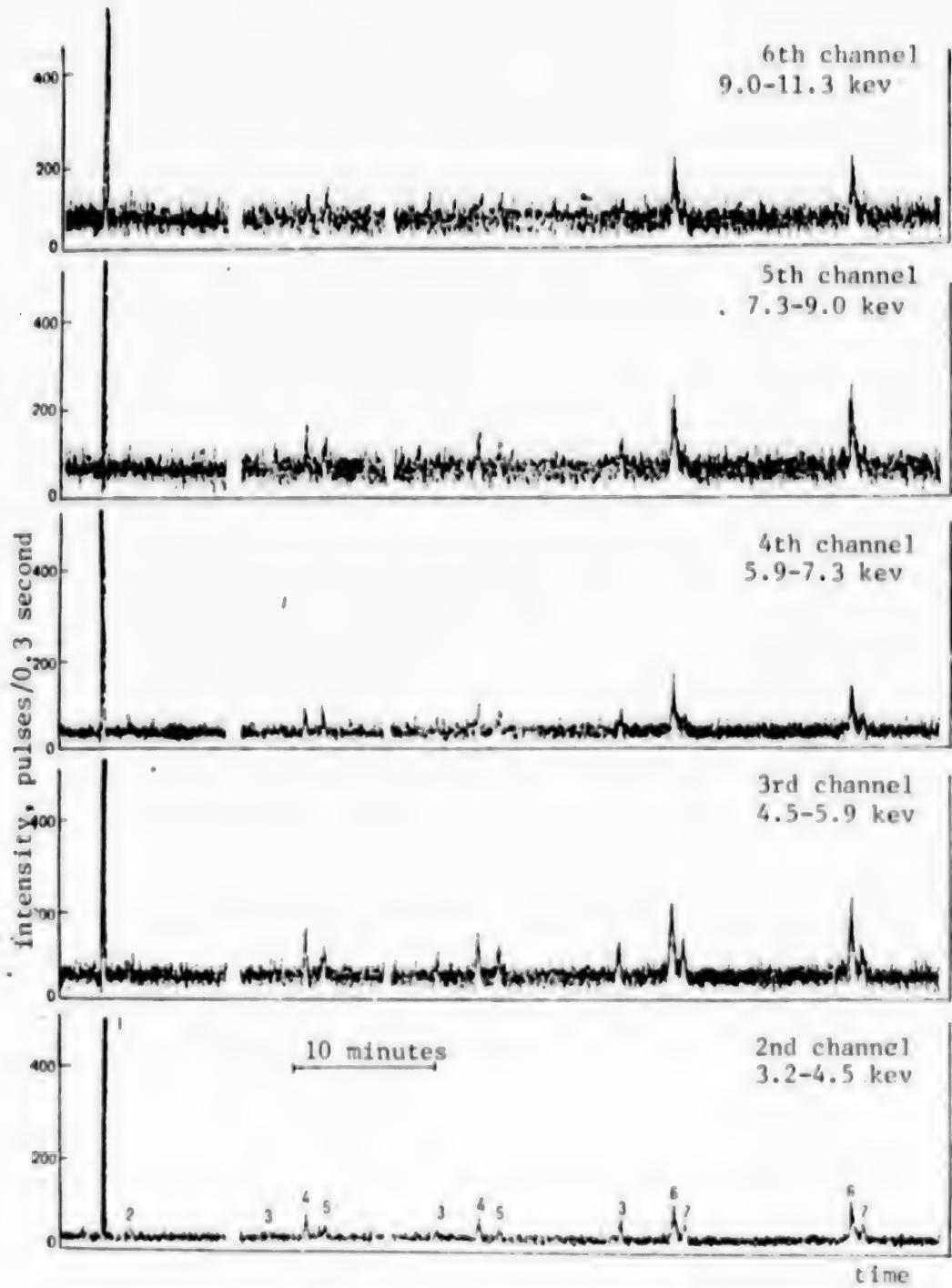


Recording of a flare of radiation from a "fast burster"  
obtained by the x-ray telescope-spectrometer  
on 13 April 1983  
(energy range 2-25 kev)

Before the start and after the burst a large constant level of radiation from the burster could be seen.

The "disappearance" of Hercules X-1 was also confirmed by observations from the European Exostat satellite. At the same time, "optical" observers informed us that the curve of brilliance of the variable HZ of Hercules virtually did not change. At the same time, changes in the brightness of this star are explained by the conversion in the stellar photosphere of the X-radiation of the neutron star. Hence, the neutron star comprising the binary obscured pair "shines" as before. Obviously the changes occurred only in the gaseous disc surrounding the neutron star from which matter falls on the neutron star (the accretion disc). This disc is responsible for the soft X-radiation from the system. Possibly the angular diagram of radiation has changed which now passes through the "eye of the observer." Theoreticians will have to rack their brains over this puzzle as the radiation from the source Hercules X-1 has remained stable for more than a decade.

Several times Astron observed the "fast burster" (MXB 1733-35) which is located close to the center of the galaxy at a distance of 10,000 parsecs from us (ZEMLYA I VSELENNAYA, 1980, No 6, p 27.--Editors). This is a close binary system consisting of a neutron star and a red dwarf in which darkenings are not observed, either x-ray or optical. The reason for the x-ray bursts of the



Recording of radiation in different channels of the x-ray telescope-spectrometer made during the scanning of a portion of the heavens on 9 July 1983.

On the lower figure the numbers designate identified radiation sources 1--Scorpius X-1, 2--Norma X-1, 3--sources 4U 1728-24 and 4U 1730-22, 4--source 4U 1728-34, 5--Aquila X-1, 6--galactic center, 7--Scorpius X-6.

burster is the nuclear explosion of matter which has accumulated on the surface of the neutron star. The slow flow of matter from the red dwarf to the neutron star provides a supply of nuclear fuel (primarily helium and then hydrogen). Over the 6 months of the operation of the Astron satellite, the "fast burster" three times changed the nature of radiation: we recorded bursts of different types and varying duration. Observations of this interesting object are continuing.

On 16 August 1983, the Astron satellite observed an eclipse of the "fast burster" by the moon. In proximity, at a distance of around  $0.5^\circ$  from the "fast burster" is yet another burster MXB 1728-34 which emits simultaneously also constant X-radiation. The x-ray spectrometer took the total signal of the two sources. At the moment of the eclipse of the "fast burster" there was a sharp drop in the signal. After the source moved out from the edge of the moon, the signal rose to its former level. From this it was concluded that during the observation of the "fast burster" instead of separate short pulses, constant or steady radiation had been received. This result was unexpected. From the moments of the eclipse we were able to localize the source in the celestial sphere with an accuracy of  $6\text{-}8'$ . At present, the "fast burster" is being identified with the optical objects.

The eclipses of the x-ray sources make it possible to clarify the coordinates of those of them which have not been identified with optical objects, to separate the x-ray radiation of close-lying sources and this is difficult or simply impossible to do using other methods. We are investigating 2 months ahead of time whether the moon will eclipse any other bright x-ray source and are planning to observe this.

The x-ray spectrometer of Astron also participated in synchronous observations of the sources together with the IUE international ultraviolet satellite. Under this program certain ground optical and radioastronomical observatories have been working in our country and abroad.

We have described only the first preliminary results of the observations which are being conducted on the x-ray telescope-spectrometer of the Astron satellite. The observations are continuing and powerful computers are processing their data.

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CSO: 1866/146

## PROGRAM FOR OBSERVATIONS OF HALLEY'S COMET

Moscow ZEMLYA I VSELENNAYA in Russian No 1, Jan-Feb 84 pp 35-39

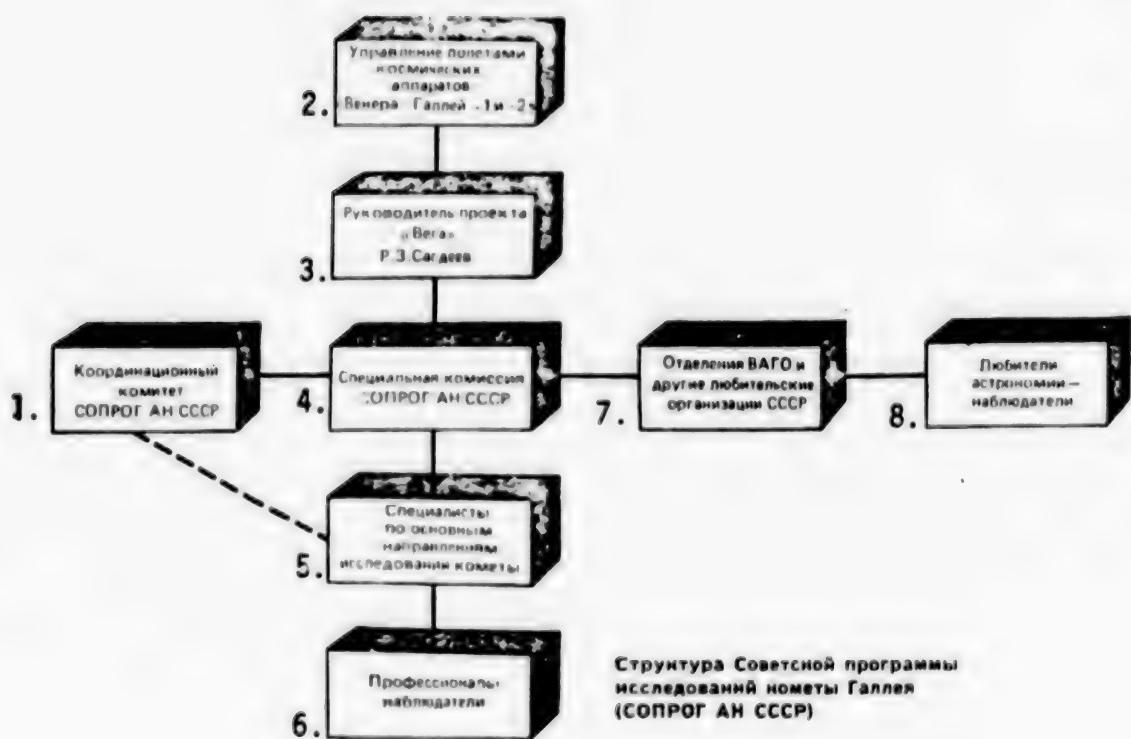
[Article by Ya. S. Yatskiv, corresponding member USSR Academy of Sciences, and K. I. Churyumov, candidate of physical and mathematical sciences: "International Program for Observations of Halley's Comet"]

### [Excerpt] The Soviet Program

Mindful of the major contribution of this country's scientists to comet astronomy and the importance of the active participation of Soviet astronomers in the observation of Halley's comet, the Soviet program of research on Halley's comet from the earth has been designed to serve as a regional part of International Halley Watch (IHW). Work of the Soviet program is under the direction of the Central Astronomy Observatory of the USSR Academy of Sciences, known for its studies in comet astronomy. A special commission has been created whose members include O. V. Dobrovolskiy (Institute of Astrophysics of the TSSR Academy of Sciences), S. P. Mayor and L. M. Shul'man (Central Astronomy Observatory of the USSR Academy of Sciences), K. I. Churyumov (Kiev University), E. A. Akim (Institute of Applied Mathematics of the USSR Academy of Sciences), Yu. V. Batrakov (Institute of Theoretical Astronomy of USSR Academy of Sciences), C. K. Vsekhsvyatskiy (Kiev University) and A. G. Masevich (Astronomy Council of USSR Academy of Sciences). The commission is chaired by Ya. S. Yatskiv, the director of the Central Astronomy Observatory of the UzSSR Academy of Sciences.

The Soviet program calls for astronomical observations of Halley's comet to be carried out at 17 observatories in our country and astrophysical observations at 15 observatories. All branches of the All-Union Astronomy and Geodesic Society will take part in the visual observations.

Within the Soviet program for earth study of the Halley Comet, there are plans being made for two specialized stations equipped with identical instruments. One of these will be located on Mt. Maydanak in Uzbekistan; the second will be placed in Bolivia in the city of Tarija. Sixty-centimeter reflectors will be installed at these stations, equipped with photoelectric, spectral and polarimetric instruments.



Structure of the Soviet program for study of Halley's Comet (SOPROC), USSR Academy of Sciences

1. Coordinating Committee, SOPROC USSR Academy of Sciences
2. Flight control for spacecraft "Venus - Halley-1 and -2"
3. R. Z. Sagdeev, director of Project "Vega"
4. Special Commission SOPROC, USSR Academy of Sciences
5. Specialists in basic disciplines of comet research
6. Professional observers
7. Sections of VAGO and other USSR amateur organizations
8. Amateur astronomers and observers

At the end of March 1983, a workers conference took place in Kiev on the Soviet programs of ground observation of the Halley's comet. A number of scientists were asked to design uniform instructions and recommendations on all aspects of the study.

The Soviet program of observing the comet is a long-term one, lasting from 1983 through 1987. At first, the basic observational work will be at the observatories in temperate latitudes. As Halley's comet approaches its perihelion, the work will shift to southern observatories in the Soviet Union, which will study the comet after it passes through its perihelion. During this period of the comet's greatest brightness and activity, the Soviet expedition in Bolivia will have the most to say.

Since Halley's comet will enter into conjunction with the sun several times during the period 1983 to 1987, it is natural that the program will be carried out during several periods when the comet is optically visible.

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CSO: 1866/94

UDC: 521.13

CONSTRUCTION OF A SYSTEM OF POINT MASSES REPRESENTING THE GRAVITATIONAL FIELD OF A PLANET FROM SATELLITE OBSERVATIONS. I. DEVELOPMENT OF ALGORITHM

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian No 2, Apr 84 (manuscript received 22 Jun 83)  
pp 76-86

POLESHCHIKOV, S. M., KHOLSHEVNIKOV, K. V.

[Abstract] A study is made of the problem of refining the parameters of the gravitational field of the earth based on laser observations of the slant range of a satellite and its rate of change. The model approximating the gravitational field of the planet is a system of point masses. Computation of the matrix consists of solution of variational equations. Numerical results from processing of experimental materials are promised in a future article.

[156-6508]

UDC 521.9

PARAMETERS OF EARTH'S ROTATION FROM LASER RANGING BY LAGEOS ARTIFICIAL EARTH SATELLITE DURING INITIAL OBSERVATION SESSION IN MERIT PROGRAM

Moscow PIS'MA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 10, No 6, Jun 84  
(manuscript received 21 Nov 83) pp 465-468

NESTEROV, V. V., State Astronomical Institute imeni P. K. Shternberg, Moscow

[Abstract] Results are shown from processing of 400,000 topocentric distances measured by the LAGEOS satellite during the period August through October 1980 during 841 passes of the satellite over 12 NASA stations and 3 SAO stations as part of the MERIT (Monitoring of Earth Rotation and Intercomparing the Technique of Observations and Analysis) program. The first stage of processing consisted of ordering distances in a standard format and smoothing using the Vondrak method (1969). This resulted in 5,985 normal distances, which made up the initial observation material. Computed topocentric distances to the

satellite were found using the analytical theories of satellite movements (intermediate orbit based on the Akane theory (1970), perturbations from the Earth's gravitational potential (the GEM10 model), direct and tidal lunar-solar perturbations (the Nesterov algorithm, 1983), perturbations from light pressure (Akane, 1976), tidal shifts in the coordinates of the observing stations (Cartwright and Taylor 1971, Wahr 1981), and corrections to universal time resulting from zonal terrestrial tides (the formulas of Yoder et al., 1970)). Differences found between observed and computed topocentric distances formed the basis for subsequent differential improvement of the satellite orbit. Root-mean-square residuals for the orbital fitting were 50-80 centimeters for a 5-day interval. Accuracy of results was greater than that obtained using conventional methods. It is concluded that the analytical theories forming the basis for the algorithms used can be employed in high-accuracy laser observations of the Earth's rotation. Figures 2; references 10: 2 Russian, 1 Czechoslovak, 7 Western.  
[9642-179]

UDC 520.8

#### FEASIBILITY OF A POSTERIORI PROCESSING OF ASTRONOMICAL IMAGES

MOSCOW PIS'MA V ASTRONOMICHESKIY ZHURNAL. in Russian Vol 10, No 6, Jun 84  
(manuscript received 27 Sep 83, after revision 1 Jan 84) pp 469-473

TSVETKOVA, V. S. and CHERNYY, V. G., Astronomical Observatory, Kharkov State University imeni A. M. Gorkiy

[Abstract] The feasibility of a posteriori processing of astronomical images using the method of coherent optics is discussed. Optical enhancement in a posteriori processing was attempted with the Kharkov State University processor, which is able to handle the large amounts of data found in astronomical images ( $10^5$ - $10^6$  bits). Images of the planet Jupiter were used to illustrate the method. The method is based on effects associated with the quantum nature of light and its interaction with today's highly sensitive photographic films. Isopanchrom T-22 was used in this experiment. For Jupiter, photon fluctuation is about 1% with a buildup time of 4.0 seconds needed to create the density for darkening the photographic films. The magnitude of the detection quantum effectiveness, which determines the signal-to-noise ratio, is less than 0.3%. This means that recording error at optimal image scale is about 5%. The inadequacy of this standard is resolved either by adding a series of copies of the same image with subsequent filtering or by filtering a single image and then adding images. Procedures for matching film resolution and spatial resolution are explained. The results from enhancement of the Jupiter images are shown. It is concluded that a posteriori processing makes it possible to obtain images of extensive astronomical objects at double the resolution of the original images, reaching resolutions within 0''.2-0''.3 of orbital resolution when ground telescopes have been used. Figures 3; references 9: 4 Russian, 5 Western.  
[9642-179]

UDC 520.3

## ACOUSTOOPTIC SPECTROMETER FOR RATAN-600 TELESCOPE

Moscow PIS'MA V ASTRONOMICHESKIY ZHURNAL in Russian Vol 10, No 6, Jun 84  
(manuscript received 24 Oct 84 [as published], after revision 6 Feb 84)  
pp 474-480

YESEPKINA, N. A., RYZHKOV, N. F., GRACHEV, V. G., KOCHERGINA, I. S.,  
PRUSSZHUKOVSKIY, S. V. and SHISHKIN, A. I., Leningrad Branch of the Special  
Astrophysics Observatory, USSR Academy of Sciences, Pulkovo

[Abstract] A description is given of the design and operation of an acoustooptic spectrometer developed for use with the RATAN-600 telescope. The spectrometer is made up of an electronic section (spectral receiver, built on a heterodyne circuit with a low-noise amplifier at the input), an optical section (an acoustooptic spectrum analyzer) and a digital section (a computer with monitoring and recording devices and an SPU-1 program control system). Observations using this equipment were conducted in 1981 and 1982 in the neutral hydrogen line ( $\lambda = 21 \text{ cm}$ ) and water vapor line ( $\lambda = 1.35 \text{ cm}$ ) using SP-21 spectral receivers and a cooled FET amplifier, and an SP-1.35 spectral receiver with a quantum amplifier. The spectrum analyzers, measuring  $430 \times 220 \text{ mm}$ , were made from TF-3 glass and installed in a peripheral operating with an Elektronika-100I computer. Further details of the hardware and software are given. Observations were made of sources Orion A-KL, W 51, W 16, W 44, W 49, G3, G7 and G9. Findings were compared with similar observations made using a standard AS-30-40 spectrum analyzer. The results demonstrate that this kind of spectrometer can be used as part of automatic spectral complexes, offering an extensive range of analysis in a large number of spectral channels and ease in altering analyzer parameters. Figures 7; references 8: 6 Russian, 2 Western.

[9642-179]

UDC: 523.927+52.337

## TRANSFER OF MAGNETIC FIELDS IN TURBULENT ENVELOPE OF THE SUN

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 61, No 2, Mar 84  
(manuscript received 21 Jan 83) pp 354-365

KRIVODUBSKIY, V. I., Astronomical Observatory Kiev State University

[Abstract] The turbulent viscosity and transfer speed of the large scale magnetic field in the photosphere and convective zone of the sun resulting from turbulent diamagnetism are calculated. A study is made of the problem of transfer of the azimuthal magnetic field through the convective zone considering the diamagnetic effect. In the lower half of the convective zone the diamagnetic field acts against magnetic buoyancy. The equilibrium magnetic field permissible in the field descent area is estimated considering

the effect of magnetic buoyancy and turbulent diamagnetism. The characteristic transfer time of fields to the surface is significantly less than half a solar cycle. Figures 4; references 27: 14 Russian, 13 Western.  
[136-6508]

UDC: 620.274+521.9:524.3-52

#### RESULTS OF ASTROMETRIC EXPERIMENT WITH CRIMEA-PUSHCHINO INTERFEROMETER

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 61, No 2, Mar 84  
(manuscript received 24 Dec 82) pp 375-381

ZHAROV, V. Ye., KOGAN, L. R. and SOROCHENKO, R. L. and FEDOSEYEV, Ye. N., State Institute of Astronomy imeni T. K. Shternberg; Institute of Space Research, USSR Academy of Sciences; Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] An analysis is presented of astrometric results obtained with the Crimea-Pushchino radio interferometer in July of 1981. The interferometer operates at a wavelength of 1.35 cm using quantum paramagnetic amplifiers, hydrogen frequency standards and recording systems. The interferometer consists of two identical RT-22 radiotelescopes located in the village of Katsiveli in the Crimea and at Pushchino near Serpukhov, about 1200 km apart along a north-south line. Three radiation sources were observed 15-17 July: Orion-A, W49 M, W51 MAIN. Corrections to the base and difference in nominal frequencies of local oscillators were obtained. Large accumulations of sources must be observed to decrease the errors in these parameters. Figures 2; references 9: 7 Russian, 2 Western.  
[136-6508]

UDC: 521.9

#### DETERMINING SCALE IN HOMOGENEOUS REDUCTION OF INTERNATIONAL LATITUDE SERVICE OBSERVATIONS

Moscow ASTRONOMICHESKIY ZHURNAL in Russian Vol 61, No 2, Mar 84  
(manuscript received 14 Dec 82) pp 382-384

RASULOV, R. M., Main Astronomical Observatory, Ukrainian Academy of Sciences

[Abstract] A test was made to see how successfully scale errors had been determined and eliminated in homogeneous processing of ILS observations. It was found that the Yumi-Yokoyama corrections substantially improved the results of ILS observations. An additional correction is computed

The solution of problems of space medicine is very important to public health practice. This applies, in particular, to work on evaluation of states and diagnosis of states during exposure to extreme factors, in-depth investigation of effects on the body of such factors as hypokinesia, stress, altered environment, refinement of biotelemetry to record medical information and for diagnostic purposes, as well as solving problems of prevention and rehabilitation.

The problem of man's adaptation to gravity is of special interest in connection with space exploration.

Large living organisms, including man, react distinctly to a change in gravity. For smaller ones, for example insects, surface tension forces are of much greater significance, while microorganisms are indifferent to gravity and live in a world of viscosity and brownian movement.

Nature performed two major experiments in the course of evolution, which were related to biological overcoming of gravity. The first occurred when living beings moved from the water to land and the second, when man's ancestor began to walk erect. The most important result was refinement of the structure and function of the cardiovascular, locomotor and central nervous system.

"Vertical" organization of the human body in the field of earth's gravity is an exquisite creation of nature. It gave man enormous advantages, including social ones, but also generated some biological problems. Man spends a considerable part of his life, and the most active one at that, in erect position. This involves the necessity of continuously retaining the center of gravity in unstable equilibrium, constant function of muscles, particularly those of the legs, to maintain the assumed pose, and as a result the mass of man's lower extremities is close to half the mass of his entire body, while the level of motor activity is very important to the normal course of physiological processes in the entire body.

In contrast to man, there are very few mammals that voluntarily assume an erect position, and then only for brief times. The fact that man can do this without difficulty is a major evolutionary achievement.

It should be noted that gravity, within the range that we encounter on earth or in space, does not have a direct effect (influence) on the molecular, sub-cellular or cellular levels. Its direct or indirect effect begins to be manifest in organisms that have a mass of at least a few grams, and it is particularly evident in humans who have the privilege of looking at the world in erect position.

The adaptation we have achieved is phylogenetic. In the course of an individual life, we can condition and refine it, but we can also partially lose it. Most often, this happens because of age or disease. But, as it was learned, this can also occur in young, quite healthy people, if they travel in space where weightlessness prevails.

On the whole, man undoubtedly is notable for high flexibility of adaptive capacities. Where other animals limit their lifestyle to special and narrow ranges, man decisively expanded them. That he was able to achieve this is

attributable to synthesis of both his biological and intellectual capacities. It became possible for us to cause changes, not only in the environment, but in ourselves. We acquired the freedom of choice of purposeful strategy of behavior; we can improve our physiological capacities, make our life more stable, prosperous and interesting.

Unfortunately, it must be conceded that, in invading nature, man has still not learned to anticipate and prevent the undesirable consequences of his intervention with regard to the biosphere as a whole and himself.

The space environment is characterized by profound vacuum, excessively low or, on the contrary, excessively high temperatures and ultraviolet radiation. For this reason, it is necessary to provide pressurized cabins on spacecraft, which are equipped with an aggregate of rather complicated life-support systems. Future habitable installations on planets or settlements in space, about which much is being spoken in recent times, must also provide reliable protection for man against the aggressive effects of this new environment for him.

Let us examine the nature of the effects of spaceflight factors on man and the implications of such effects.

Spaceflight conditions and factors are diverse in nature. The most relevant are weightlessness, cosmic radiation, deviation of environment parameters in the craft and factors that elicit marked neuroemotional tension.

Let us begin with cosmic radiation. Galactic cosmic radiation from deep space, radiation from flares of our sun and earth's radiation belts are the sources of this radiation.

Careful dosimetry was performed during all missions. It revealed that the radiation dose absorbed by a cosmonaut during missions to the moon (crossing earth's radiation belts) constituted about 0.5 rem. It increased to 5 rem during the longest orbital missions lasting about 6 months. However, all these levels are below the adopted "allowable radiation dose."

The situation will change radically if we undertake interplanetary flights. In this case, galactic cosmic radiation, which consists of nuclei of chemical elements with a relativistic velocity, may acquire biological importance.

Weightlessness is another important factor of spaceflights. How does man react to it? On the conscious level--by more or less marked spatial disorientation and a broad spectrum of emotional reactions, positive or negative in nature. On the level of autonomic functions--by equivalents of physiological reactions that occur on earth when man's motor activity is drastically reduced (hypokinesia), when he assumes a horizontal position (bedrest) or submerges in water (immersion).

The mechanisms of functional changes in weightlessness are initially due to the following three basic causes: change in afferent part of the nervous system, removal of hydrostatic blood pressure and absence of weight on the skeleto-muscular system.

Illusions referable to the body's position or movement in space are the first manifestation of the effect of weightlessness. The illusions are related to impairment of coordinated function of such sense organs as the vestibular system of the inner ear, vision, cutaneous and muscular sensibility. Man experiences the sensation of falling or flying upside down. Unpleasant sensations of discomfort, manifested by vertigo, etc., are often added to this.

Somewhat later is a group of reactions that are initially caused by the lack of hydrostatic blood pressure in weightlessness, since blood itself becomes weightless. As a result, there is redistribution of mass of circulating blood; blood passes from the lower part of the body to the upper. The increasing influx of blood to the heart increases its intrathoracic volume. This situation is perceived as an emergency by the nervous elements that control the volume and pressure of circulating blood. There is triggering of regulatory mechanisms that lead to reduction of circulating blood volume. Here, an important role is played by diminished production of corresponding hormones, as a result of which the kidneys excrete more fluid and electrolytes. Concurrently, there is a diminished thirst and a negative fluid balance is established. The weight loss at the first phase of flight is attributed expressly to this. The visible signs are hyperemia and edema of the face, redness of the eyes. As a result, the phenomenon of "deconditioning of the cardiovascular system" may appear after 2-3 weeks of flight.

With further exposure to weightlessness, the next group of reactions appears, this one due to removal of weight from the skeletomuscular system. Underloading the muscles, particularly tonic ones which, as we know, organize and maintain a specific position, leads to their partial atrophy. This is reflected by a change in protein and electrolyte metabolism, as well as general energetics of the body. There is noticeable change in coordination of movements, and the entire nature of motor activity acquires new features: man does not walk, rather, he floats in the spacecraft. At this time, loss of muscle mass, chiefly referable to muscles of the lower extremities and back, starts to have the most significance in the structure of weight loss.

With reference to bones, one observes signs of osteoporosis related to loss of calcium and phosphorus salts. Thus far, calcium loss and, consequently, change in strength of the skeleton, have not become threatening, even in the longest missions. However, until we learn to reliably eliminate these phenomena, they may become an obstacle to extending missions.

Nevertheless, on the basis of accumulated experience, the impression as a whole is formed that man can adapt satisfactorily to prolonged weightlessness. It is quite apparent that such adaptation is related to physiological and, in part, anatomical changes in the body. On the other hand, adaptation to weightlessness signifies, to some extent, loss of man's adaptation to customary conditions on earth.

All people who have been in orbit experience certain difficulties, often significant ones, expressly after returning to earth.

This is one of the reasons why special screening of candidates is done for participation in spaceflights, medical monitoring is done during missions, and why

it is mandatory for cosmonauts to use a special system of protective and preventive measures that minimize the adverse sequelae of weightlessness effects.

The strategy of medical support of missions amounts to controlling the health status of cosmonauts, more specifically, control of adaptation processes so that man would adapt moderately to weightlessness without losing adaptation to the customary gravity on earth.

Let us discuss briefly the problems of reliability and risk.

They amount, in essence, to continuous improvement of flight safety by improving reliability of both space equipment and man.

In defining the safety level or "allowable risk," it is necessary to take into consideration possible inflight changes in health status, long-term implications to health and genetic changes.

Analysis of the nature and incidence of diseases among cosmonauts fails to reveal any differences from morbidity among pilots of jet aircraft and helicopters. The same applies to preliminary evaluation of long-term consequences and genetic changes. How can one assess the risk?

We can be guided by evaluation of the risk of demographic failure on the basis of data referable to the last 20 years of space missions. It was found that the demographic failure risk for cosmonauts is the same as for test pilots and professional boxers.

The main task of space medicine is to assure the safety and reliability of man during spaceflights. In practice, this means implementation of the already existing and rather well-developed system of medical measures.

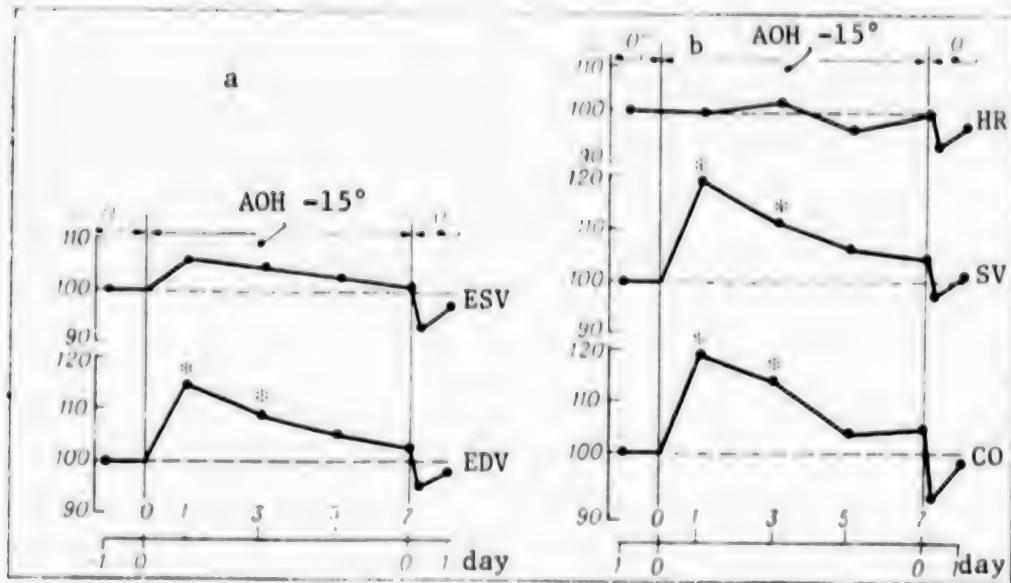
These measures include screening and training of crews on the basis of medical criteria, sanitary and hygienic monitoring of habitat in a spacecraft and operation of life-support systems, medical monitoring of crew's health status and rendering medical care, performance of a set of preventive measures to stabilize physical condition and preserve the crew's work capacity.

Our knowledge and knowhow are growing from flight to flight. This makes it possible to take each successive step with greater confidence and to achieve more significant results.

The prospects of operating permanent orbital platforms, where people can live and work in space for a virtually unlimited time, are emerging with increasing clarity.

It will be possible to achieve such plans, which are outstanding in implications and boldness, only when space exploration will develop in a peaceful direction for the good of all people.

At the present stage of development of space medicine, the objectives of physiological research in this area are related to increasingly complicated flight conditions, repeated participation in missions of the same cosmonauts,



Changes in ESV and EDV of left ventricle (a) heart rate (HR), SV and CO (b) of healthy males ( $n = 6$ ) during 7-day AOH with  $-15^\circ$  body tilt

X-axis, time (days); y-axes, corresponding change (%) in relation to background. Asterisk shows statistically reliable change in relation to background (horizontal position).

Analogous changes were also present in mean cardiac SV and CO, a significant and statistically reliable ( $P < 0.05$ ) increase in which (by 19–20%) was noted only on the first 3 days of AOH (see Figure, b). And, just like the volume of the left ventricular chamber in systole and diastole, SV and CO values were somewhat lower at the first stage after AOH than before hypokinesia. It should be noted that a similar secondary decrease in heart volumes had been observed in cosmonauts right after completion of a mission (G. A. Fomina, 1979; W. Henry et al., 1975).

An inherent distinction of the heart's reaction to 7-day AOH was absence of clinically significant and statistically reliable changes in echocardiographic parameters reflecting myocardial contractility, including the most informative parameters, such as EF, SS and RCS.

There were similar patterns of echocardiographic parameters reported by several authors with simulation of hemodynamic effects of weightlessness by submerging healthy people in an immersion medium. Thus, according to the data of A. M. Babin (1983), 7-day "dry immersion" (Ye. B. Shul'zhenko, 1975) of essentially healthy subjects was associated with statistically reliable ( $P < 0.05$ ) increase of ESV and EDV (by 14–23%) of the left ventricle, as well as SV and CO (by 23–25%), without appreciable changes in echocardiographic parameters of myocardial contractility. And, as was the case after AOH ( $-15^\circ$ ) and spaceflights of different duration, after coming out of the immersion medium the absolute values of the above-mentioned volumetric echocardiographic parameters were lower, not only in comparison to the last day of immersion, but background levels.

Comparatively more marked increase in heart chamber volumes was noted by several authors when subjects were submerged in seated position, which was associated with marked increase in central blood volume, central venous pressure, as well as intrathoracic and transmural pressure (M. Arborelius et al., 1972).

The cardiovascular changes observed with AOH and immersion were not pathological in nature, they were not associated with appearance of echocardiographic signs of impaired myocardial contractile function and were consistent with changes observed under such experimental conditions in central and peripheral hemodynamics, namely, marked redistribution of blood in a cranial direction and, as a consequence of this, increased venous return to the heart, as well as possible increase, under these conditions, of pressure in its chambers and system of the pulmonary artery (Kh. Kh. Yarullin et al., 1980; Ye. I. Vorob'yev et al., 1979; V. Ye. Katkov et al., 1978, 1979).

Of course, plethora of intrathoracic vessels and cardiac chambers observed in simulated and real weightlessness leads to development of corresponding compensatory and adaptive reactions of the cardiovascular system, which are aimed at hemodynamic unloading of the heart and pulmonary circulation, as well as providing a CO that is adequate to the body's requirements.

One of the main triggering mechanisms of these compensatory reactions is apparently stimulation of reflexogenic baroreceptor zones of the heart, lungs and beginning segment of the arterial bed (especially of the atria, aorta and carotid sinus), which leads to expression of "unloading" reflexes directed toward normalization of pressure and blood flow in central and peripheral vessels (V. V. Parin, 1939; V. V. Parin and F. Z. Meyerson, 1965; K. Schwieg, K., 1935), i.e., reflexes, in discovery and description of which V. V. Parin played a significant part.

In the opinion of most specialists working in the field of space medicine, one of the main mechanisms of acute adaptation of the human cardiovascular system to weightlessness is also a decrease in circulating blood volume as a result of the Henry-Gauer reflex in response to stimulation of volumoreceptors of the left atrium caused by increased delivery of blood to the chambers of the heart (V. V. Parin, 1939; A. I. Grigor'yev, 1980; O. Gauer, J. Henry, 1956, 1963; O. Gauer et al., 1970; O. Gauer, 1973).

Unloading of intrathoracic vessels and the heart, as a result of adaptive change in tonus of peripheral vessels and, as a consequence, deposition of blood in vessels of the abdominal cavity and other vascular regions (V. I. Lobachik et al., 1975) may be another equally significant mechanism for normalizing hemodynamics in weightlessness.

The nature of cardiac adaptation to changes in central and peripheral hemodynamics at different stages of real and simulated weightlessness depends appreciably on the adequacy and efficacy of these compensatory reactions.

It should be stressed that the dynamics of echocardiographic parameters of the subjects during 7-day AOH and immersion were characterized by marked

including middle-aged ones, the need to retain high work capacity for the duration of the missions, refinement of the system of diagnosing states, medical monitoring and prevention.

The research begun by V. V. Parin, which is continued now by his disciples and coworkers, is developing well. Substantial advances have been made in solving problems of effects of spaceflight factors on the body. Many interesting data have been obtained in recent years in the area of simulating spaceflight factors by means of antiorthostatic hypokinesia and hypokinesia in an immersion medium. These conditions simulate quite adequately the effect of weightlessness on the body. Major research in this direction is being pursued by the staff of the Institute of Biomedical Problems, USSR Ministry of Health.

Important data were obtained on the effect of weightlessness on fluid-electrolyte metabolism. A. I. Grigor'yev, one of the disciples of V. V. Parin, developed the means of correcting changes in fluid-electrolyte metabolism at the final stages of space missions. B. M. Fedorov, R. M. Bayevskiy and many other disciples and followers of Vasiliy Vasil'yevich have developed pressing and important problems of space physiology and medicine.

Systems of physiologically determined rehabilitation measures have been developed and are being used with success; their use provides optimum conditions for rapid restoration of impaired body functions with the change from weightlessness to earth's gravity.

With respect to solving future problems of space physiology, of special importance is comprehensive investigation of mechanisms of processes of adaptation, deadaptation and readaptation, control of these processes in order to facilitate the transition to weightlessness and return to earth's gravity. Further research on regulatory systems of the body, circulation, fluid, electrolyte and plastic metabolism, and the locomotor system is necessary in order to identify the mechanisms of adaptation and readaptation, and develop methods of controlling them during exposure to spaceflight factors.

The work of V. V. Parin laid the foundation for investigation of these matters, and it is being developed with success, enriching space medicine theory and practice, and providing for successful development of cosmonautics.

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INTRACARDIAC HEMODYNAMICS AND HUMAN HEART FUNCTION IN SIMULATED WEIGHTLESSNESS

Moscow VESTNIK AKADEMII MEDITSINSKIKH NAUK SSSR in Russian No 4, Apr 84  
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[Article by Ye. B. Shul'zhenko, L. I. Kakurin, A. A. Savilov and A. M. Babin (Moscow)]

[Text] According to the existing hypothesis, one of the principal triggering mechanisms of changes in cosmonauts' cardiac function is redistribution of blood to vessels in the upper half of the body, which is inherent in weightlessness. This can be associated with impaired blood flow in the pulmonary circulation, increased delivery of blood to heart chambers, as well as elevation of pressure in the heart and pulmonary artery. Thus, the heart of cosmonauts apparently functions under a hemodynamic volume and pressure load in weightlessness. It is quite significant that objective and subjective signs of plethora of vessels in the upper half of the body during spaceflights may persist for a rather long time (Ye. I. Vorob'yev et al., 1969; I. I. Bryanov et al., 1970; A. D. Yegorov, 1982; W. Thornton et al., 1977, and others).

In spite of the fact that much attention was given to investigation of the effects of weightlessness and other spaceflight factors on the human cardiovascular system, some aspects of this problem are still insufficiently clear. Further purposeful investigation is required, in particular, of questions dealing with the effect of weightlessness on intracardiac hemodynamics and function of the human heart. The lack of needed volume of information on this score is largely related to the fact that, until recently, indirect, estimation methods of studying pumping and contractile functions of the heart were used for inflight cardiological studies, and their informativeness and accuracy are limited to some extent.

Our main objective here was to investigate the phenomenology and mechanisms of development of changes in hemodynamics and function of the human heart during the acute period of adaptation of the cardiovascular system to simulated weightlessness. The main experimental model of weightlessness was to have healthy males spend 7 days under strict bedrest conditions with the head tilted below the horizontal line (antiorthostatic hypokinesia--AOH). As shown by the results of previous studies, it is possible to reproduce the redistribution of blood to vessels of the upper half of the body more fully with AOH than with hypokinesia in horizontal position (A. M. Genin, L. I. Kakurin, 1972; A. V. Beregovkin, V. V. Kalinichenko, L. I. Kakurin et al., 1975; V. M. Mikhaylov et al., 1979, and others).

The distinction of this study from previous ones of the effects on simulated weightlessness on condition and performance of the human heart is that we used, as the basic investigative method, a method that is relatively new to space medicine, but one that has already made a name for itself in clinical practice for examining cardiac function--pulsed ultrasound echocardiography (V. V. Zaretskiy et al., 1979; N. M. Mukharlyamov, Yu. N. Belenkov, 1981; H. Feigenbaum, 1976, and others).

It should be stressed that this method has several substantial advantages over those used until recently in space medicine for evaluating cardiac function (L. I. Kakurin et al., 1980). The main advantage of echocardiography is that it is possible not only to assess qualitatively, but (which is particularly important) quantitatively, with rather high precision, the changes in basic parameters characterizing cardiac architectonics, intracardiac hemodynamics, pumping and contractile functions of the heart. It is also very relevant to space medicine that this method is absolutely harmless, it does not require intravascular intervention and does not elicit undesirable side-effects in the form of changes in circulatory system function of the subjects. In actuality, it fully meets the right requirements imposed on methods for medical examination of cosmonauts in flight and, provided the appropriate equipment is there, can be used on orbital stations.

The studies were conducted using the conventional method of clinical medicine with a series-produced Echoview-80C echocardiograph of the Pikkor Firm (United States). In interpreting the recorded echograms, we measured and calculated the following main parameters: thickness, amplitude and rate of movement of the interventricular septum and posterior wall of the left ventricle; diameter of the aorta and left atrium, as well as left ventricle in systole and diastole, end systolic (ESV) and end diastolic (EDV) volumes of the left ventricular chamber, stroke volume of the heart (SV), cardiac output (CO), as well as ejection fraction (EF), degree of shortening of anteroposterior size of left ventricular chamber in systole (SS) and rate of circular shortening of myocardial fibers (RCS). To record the echocardiogram and calculate the parameters, we used the recommendations followed in clinical practice (N. M. Mukharlyamov, Yu. N. Belenkov, 1974, 1981; V. V. Zaretskiy et al., 1979; L. Deichholz et al., 1972; R. Popp, D. Harrison, 1974; H. Feigenbaum, 1976).

At the first stage of our work, the objective was to study changes in human heart function during brief (10-15 min) stay in antioorthostatic position (AOP) with the body tilted at different angles (from -4° to +30°) in relation to the horizontal line. Analysis of the material obtained revealed that increase in systolic and diastolic heart volumes, as well as CO, were the most typical manifestations of the heart's reaction to the change in tolerance of this factor, the above-mentioned changes were not associated with appreciable changes in echocardiographic parameters characterizing myocardial contractility (EF, SS, RCS). The absolute values for ESV and EDV of the left ventricle, SV and CO reverted to base levels virtually immediately after returning the subjects to horizontal position.

The pattern of changes in the parameters of diastole or stroke, i.e., pumping function of the left ventricle that we studied corresponds with the results of previous studies, in which it was found that the heart of healthy subjects

to ADP is associated with marked increase in return of venous blood to the heart and blood-filling of vessels in the upper half of the body (D. A. Aleksayev, 1974; I. D. Pestov, 1974; G. Blomqvist et al., 1980; J. Nissen et al., 1979; U. Cebhardt et al., 1980, and others), and, as indicated by the results of radioisotope studies (V. I. Lobshik et al., 1975, 1982; Yu. I. Vagab'yan et al., 1979) and studies involving cardiac catheterization (V. Ye. Saten et al., 1978, 1979, 1982; V. V. Chertukhin et al., 1981), in IR (at angles of -15° to -30°) there is not only increase in delivery of blood to intrathoracic vessels, but marked elevation of pressure in cardiac chambers and the pulmonary artery, as well as in tension developed by the heart.

Thus, the dynamics of echocardiographic parameters demonstrated when subjects were changed to ADP were clearly related to the observed hemodynamic changes, and they indicated that, under such conditions, the basic heart functions under a volume and pressure load.

Use of ultrasound echocardiography during the antigravitational tests made it possible to make a quantitative assessment in a noninvasive way of the changes that occurred in condition and performance of the heart, and thereby to assess substantially the informativeness of this functional test. In fact, with use of this method, it is possible to use the IR test not only as gross functions of the cardiovascular system as a whole, but to detect functional reserves and individual compensatory and adaptive reactions of the heart of subjects, including dynamics, in order to evaluate the degree of their accustomedness to gravitational redistribution of blood.

It should be stressed that the extent of increase in volume ultrasonographic parameters observed in ADP depended on the size of the angle of inclination of the body in relation to the horizontal line. Thus, with a head-down tilt of 6° the increase in LV and RV IRs was small (on the average 4 and 7%, respectively), whereas with a 30° tilt, it reached 32 and 20%. Analysis of the findings revealed that the test with a -30° angle of ADP, upon which there was also marked and persistent increase in IRV, IRW, LV and RV, is the most informative as a functional test for examination of cardiac function. However, such a large angle was found to be unacceptable for subsequent use of -15° to -30° for periods of up to 7 days. The reason for this was mainly that the subjects developed unpleasant sensations related to marked redistribution of blood and difficulty of maintaining for 7 days a specified, fixed body position at such a large angle in relation to the horizontal line.

For this reason, at the second stage of our studies, when body position could be kept at angle of -15°, at which no marked adverse feelings developed than with an angle of -30°, increase in IRs of the left + right chamber, LV and RV. Moreover, the subjects believed this could be satisfactory, without appearance of marked unpleasant sensations.

The change in volumes of the left ventricle during tests performed at a tendency toward 6% increase in IRV, as well as marked and significant ( $P < 0.05$ ) increase of IRs (in IRW). Second regression at separate base level of IRV and IRW starting on the 26-28 day of the year displayed feature in the dynamics of these parameters (see Figure, 3).

for the micrometer value  $R_C$  used to compute the latitude of the Carloforte station from July of 1938 through March of 1939. A table presents the corrections to the coordinates of the pole published by YumI and Yokoyama and the recommended values of x and y following these corrections.

Figures 1: references 3: 2 Russian, 1 Western.

[136-6508]

UDC: 629.78:612.08

RESULTS AND PROSPECTS OF PHYSIOLOGICAL RESEARCH DURING SPACEFLIGHTS

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(manuscript received 29 Jul 83) pp 7-11

[Article by O. G. Gazeiko (Moscow)]

[Text] The development of space medicine, appearance of new problems in physiology in connection with preparation for and performance of the first spaceflights are inseparably linked with the life and endeavors of the outstanding Soviet scientist, Vasiliy Vasil'yevich Parin.

V. V. Parin was one of the leaders in physiological research conducted on animals during flights in ballistic rockets and artificial earth satellites. He made a large contribution to preparations for Yuriy Gagarin's spaceflight and medical support of the first mission. V. V. Parin defined the main directions of development of space cardiology.

Prompt and comprehensive development of problems of space physiology makes it possible to successfully implement medical support of missions, monitor the health status of cosmonauts, use an effective enough system of preventive and readaptation measures.

It is possible to simulate the effect of some spaceflight factors on man under ground-based conditions, by using prolonged antigravitational [head-down tilt] hypokinesia, submerging man in an immersion medium, long-term stay in pressure chamber, exposure to accelerations, stressors, etc. The results of ground-based studies play a substantial part in solving many problems of space physiology.

Studies conducted during spaceflights are of particular importance. To date, vast material has been accumulated, including studies of cardiac activity, vascular tonus, hemodynamics, skeletomuscular system, blood, fluid, electrolyte and hormone metabolism, condition of the central nervous system, etc.

The physiologically validated system of preventive measures used during missions makes it possible to perform long-term flights without deviations in status of vital systems that would be hazardous to man. The last 211-day mission enriched space medicine with new and important data, indicative of individual manifestations of circulatory changes in flight, course of adaptation and readaptation processes, efficacy of preventive measures.

individuality, particularly in the second half of the experimental period, when their condition and extent of observed changes depended largely on individual distinctions of adaptation to AOH and immersion, i.e., adequacy and quality of adaptive-compensatory reaction of the circulatory system. The severity of the noted changes in echocardiographic parameters also depended on constitutional distinctions of the subjects and their initial functional state, particularly that of the cardiovascular system before starting the tests.

Previously, tests with water immersion revealed a clearcut dependence of compensatory diuresis on level of initial hydration of the subjects' body. Thus, in those with normal hydration there was increase in excretion of free fluid, whereas in dehydrated subjects there was increase in osmolar clearance (H. Sandler, 1981).

Several authors also found, when subjects changed to AOP, a substantial difference in dynamics of pressure in the cardiac chambers, particularly the right atrium and ventricle (V. Ye. Katkov et al., 1981).

Thus, in order to demonstrate the most typical reactions of the heart in the acute period of adaptation to simulated weightlessness, it is necessary to continue the echocardiographic studies with involvement of healthy subjects differing in tolerance of gravitational redistribution of blood. Such work would make it possible to make a more complete study of the distinctions in the adverse hemodynamic effects of weightlessness on human heart function and predict more accurately individual distinctions of cosmonauts' cardiovascular system reactions when they are exposed to weightlessness.

On the whole, the data obtained to date are indicative of the theoretical possibility of using AOH and "dry" immersion for ground-based simulation of hemodynamic effects of weightlessness. However, the final answer to the question of which of these experimental models of weightlessness permits most adequate simulation of changes that occur in flight in intracardiac hemodynamics and function of the human heart can only be obtained after comparing the results of experimental studies to the results of analogous inflight echocardiographic studies of cosmonauts. The feasibility and benefit of such studies are very clearly evident from the advances made by Soviet specialists with regard to development of portable medical equipment designed for use under the specific conditions of spaceflight, as well as the successful fulfillment of the extensive program of echocardiographic studies during the joint Soviet-French flight aboard the Salyut-7 orbital station.

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COSMONAUTS' CARDIOVASCULAR SYSTEM FUNCTION DURING LONG-TERM ORBITAL FLIGHTS  
ABOARD SALYUT-6 STATION

Moscow VESTNIK AKADEMII MEDITSINSKIH NAUK SSSR in Russian No 4, Apr 84  
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[Article by A. D. Yegorov, O. G. Itsekhovskiy, V. F. Turchaninova, I. V. Alferova, A. P. Polyakova and V. I. Bernadskiy (Moscow)]

[Text] Evaluation of functional state of the cardiovascular system during long-term spaceflights is made by means of functional tests with use of lower body negative pressure (LBNP) and graded physical loads (GPL) on a cycle ergometer. The former test simulates orthostatic factors in weightlessness and permits determination of readiness of postural mechanisms for gravity forces. The latter test makes it possible to evaluate the work capacity of cosmonauts according to their hemodynamic reaction to a specific physical exercise.

Orthostatic tolerance during spaceflights is given much attention, since a decrease in it reflects, to a significant extent, deconditioning of the cardiovascular system with regard to gravity loads. Intensification of the reaction to orthostatic tests and LBNP was observed in cosmonauts following most space missions, regardless of their duration (Ye. I. Vorob'yev et al., 1970a; Ye. I. Vorob'yev et al., 1970b; Berry, 1961). More marked changes in parameters of the circulatory system to LBNP, as compared to preflight patterns, were also noted during flight aboard orbital stations of the Salyut type (V. A. Degtyarev et al., 1974, 1977, 1980) and Skylab (R. Johnson et al., 1974). During the Salyut-1 mission, data were also obtained for the cosmonauts that indicated some elevation of circulatory parameters under the influence of exercise (V. A. Degtyarev et al., 1974). These phenomena were related to development of signs of deconditioning of the cardiovascular system under the influence of weightlessness factors. At the same time, in crew members of Salyut-4 and Skylab, for whom physical exercise was increased, the general reaction of the circulatory system to a physical load in flight did not differ on the whole from preflight findings, whereas upon return to earth a substantial decline of tolerance of physical loads was demonstrable (V. G. Doroshev et al., 1977; Michel et al., 1971). The phenomenology of these changes had not been sufficiently explained in studies referable to prior missions due to the limited amount of facts. Our objective here was to provide an overall

assessment of cardiovascular reactions to the ground-based functional tests in 10 members of the principal crew (cosmonauts and flight engineers--FLE) of the Salyut-6 station when their stay in weightlessness was extended to 96-185 days.

#### Scope and Methods

A pneumovacuum suit was used for LBNP; it was worn in the lower half of the body and sealed on the level of the iliac crest. Pressure conditions: -25 mm Hg--2 min and -35 mm Hg--3 min.

The load test was performed using a cycle ergometer, with pedaling at the rate of 750 kg·m/min for 5 min. During the period of telemetry communications, the following parameters were recorded: pressure in the lower gear during LBNP, kinetocardiogram from the region of the neck heart, tachosclilogram of the brachial artery and pressure mark in a compression suit (recording it about once per min), sphygmogram of the femoral artery (in the upper third of the thigh), rheoencephalogram of the right and left cerebral hemispheres. Throughout the test with the physical load, we recorded the ECG in the D2 lead, before and after the load the reograms of the trapezius with circular electrodes on the upper third of the arm, kinetocardiogram, pleogram of the femoral artery and tachosclilogram. The obtained information was transmitted to earth via telemetry channels. Data processing includes determination of heart rate (HR), stroke volume and cardiac output (Q), minimum, total, total and systolic, pulsed arterial pressure (AP), ratio of transmission of pulse wave in aorta (RPPW), duration of phase of isometric contraction, period of ejection of blood by left ventricle, interphase sufficient, time of isometric relaxation, rapid filling, actual and nodinal specific peripheral resistance (SPR). Stroke volume was calculated during LBNP to the method of Prenter-Banks (G. N. Savitskiy, 1961) and during exercise using the formula of A. V. Andreyev (1948); AP parameters were determined by the method of G. N. Savitskiy (1961) and duration of phases of the cardiac cycle by the method of L. N. Andreyev and N. B. Andreyeva (1971), as modified by G. N. Savitskiy (1961). The severity of cardiovascular reactions to inflight functional tests was compared to reactions in ground-based tests, which were considered the control.

The obtained information was submitted to statistical processing on an Ye-1933 computer. Medical parameters were studied by parametric statistical analysis. We studied the effect on physiological parameters of duration of spaceflight (factor A, in 1-day gradations during flight), time (duration between rarefaction periods as gradations for LBNP and exercise versus its elongation), as well as interaction of these two factors. The  $\beta$  method of multiple comparison that we used enabled us to compare, in the case of statistical significance of factor A, the mean values for the test in gravitational parameters and find the periods during which the tested parameters differed significantly from their preflight values.

#### Results of Tests With LBNP

With inflight LBNP, 4 cosmonauts (P. I. S., G. N. S., G. G. and O. G.-S.) presented an increase in HR, in relation to the premission values (on 16-22%) as the average in the course of the mission. There was also increase in HR

Increment in relation to base values, although it was substantial only in FLE-1 (average of 22%, versus 12%) in virtually all of the inflight tests. Conversely, in CDR-1, the HR changes in flight were less marked in 4 out of 5 inflight tests than before the mission. FLE-4 also presented a less marked reaction (+21% versus +33%).

There was different manifestation of AP dynamics during LBNP, in relation to base values: in CDR-1 and FLE-4, the increase in minimal AP observed in the preflight tests changed in flight to decline. In FLE-1, it dropped more than on earth, whereas in the other 5 cosmonauts the inflight elevation was less marked than preflight. FLE-2 showed more marked drop of end systolic AP and the FLE-1 for pulsed AP.

The distinctions of phasic changes during inflight LBNP were manifested by a more marked increase in relative duration of phases of isometric contraction, isometric relaxation, interphase coefficient and index of myocardial tension. However, the absolute inflight values for these parameters increased with rarefaction to a lesser extent than with the same test on earth.

The ejection period and phases of rapid filling in flight, with LBNP, diminished in comparison to the mean values before LBNP in most cosmonauts to a greater extent than on earth. With LBNP, the absolute values for these parameters were lower than preflight. The intrasystolic index was higher with LBNP in flight in 4 cosmonauts and lower in 2 than it was in the preflight period.

A relative decline in stroke volume was more marked than on earth in 3 cosmonauts (CDR-1, FLE-1, CDR-4), constituting a mean of 46-49% for the mission (27-40% before it). Conversely, this parameter decreased less than before the mission in 4 cosmonauts (FLE-2, CDR-3, FLE-3 and FLE-4). Cardiac output level diminished more drastically under the effect of LBNP than on earth in the crew of the first mission and CDR-4 (average 17-32% on the ground and 35-48% in flight) and less in cosmonauts of the second and third crews (31-46 and 12-24%, respectively).

The estimated SPR in the base state and with LBNP were higher than preflight; however, with rarefaction these values were below nominal levels in all of the cosmonauts (except CDR-2 and FLE-2). More marked relative increase of SPR with LBNP was observed in isolated tests on CDR-1, FLE-1, CDR-2 and CDR-4, and in a number of instances there was appreciable decline of ratio of actual to nominal values.

Absolute RPPW was above ground-based level by an average of 16-34 and 19-59% in all cosmonauts, in flight, before and during LBNP, respectively, while its relative increment with rarefaction increased (from 2-16 to 19-34%) in most cosmonauts. In 2 cosmonauts (FLE-2 and CDR-5), on the contrary, it diminished.

According to rheoencephalographic data, inflight LBNP was characterized by undulating decrease in pulsed filling of vessels of the brain, generally within the range of preflight fluctuations, with the most marked changes in parameters with rarefaction of -35 mm Hg without any definite relationship to duration of exposure to it. At the same time, virtually all cosmonauts presented individual differences in dynamics of circulatory parameters at different stages of

flight. Thus, blood filling for vessels of both hemispheres on the 14th flight day and of one hemisphere on the 49th and 77th days decreased more appreciably in FLE-1 than on earth; in the crews of the second and third missions, the reaction of pulsed filling to inflight LBNP was usually close to the minimal preflight level, and sometimes less marked. As a rule, there was increase in tonus of precapillary and postcapillary vessels of the brain, the extent of which depended on their initial state (before flight, the dicrotic and diastolic indexes rose, dropped or showed virtually no difference from pretest values, depending on the base state of arterioles and veins). With decrease in tonus of cerebral vessels at relative rest in flight, as well as in some cases with marked vasodilatation (shift of incisura below the isoelectric line), rarefaction elicited a normotonic state of arterioles that was similar to the preflight one.

In some of the studies, distinct vasoconstriction was observed with LBNP against a background of moderate hypertonus of arterioles and veins (increase of dicrotic index to 100-112%). In cases where inflight tonus was close to normotonic, dynamics of dicrotic and diastolic indexes during LBNP showed only a tendency toward increase or decrease.

Thus, during inflight LBNP tests there was increase in absolute HR and its relative increment, decline of absolute level of minimal and mean AP and elevation of pulsed AP, more marked increase in isometric phases of contraction and relaxation, more marked decrease in ejection period and phase of rapid filling, more marked increase in myocardial tension index and interphase coefficient, more marked decrease of cardiac output in 1st and 4th mission cosmonauts and less marked in crews of 2d and 3d missions, increase in absolute specific peripheral resistance with concurrent decrease in ratio of actual to nominal values, increase in absolute level of RPPW, as well as increase of relative increment with rarefaction, reduction in flight of interhemisphere asymmetry and, in a number of cases, "normalization" of vascular tonus.

The findings indicate that the LBNP test causes greater displacement of blood from the chest to abdominal organs and lower extremities situated in the zone of compression in weightlessness than on the ground. As shown by the studies on the Skylab station, inflight LBNP elicits more marked increase in leg volume (R. Johnson et al., 1974). There is more increase in inflight leg volume for the first 2 min at LBNP of -8 and -16 mm Hg, which is indicative of existence of a zone of free extensibility of veins. In the base state, the veins are apparently flattened or ellipsoid instead of round, due to low transmural pressure (J. Mellander, S. Johansson, 1968). Consequently, in weightlessness, venous return with LBNP may diminish even more than on earth, which leads to even greater decrease in stroke volume. The drastic decline of blood volume in the cardiopulmonary region apparently has a reflex effect and increases activity of the vagomotor center, as well as enhances adrenergic influences (J. Shephard, 1974). This could explain the greater changes in cardiac function during the inflight LBNP test, including more significant increase of SB, peripheral resistance and decline of stroke volume and cardiac output (V. A. Ingel'son et al., 1974, 1977, 1980; R. Johnson et al., 1979). At different stages of flight, virtually all cosmonauts presented more marked hemodynamic responses to LBNP than on earth.

The decline of absolute and mean AP, as distinctly demonstrable in FLE-1, could serve as a sign of diminished reactivity of peripheral vessels. The distinctive inflight changes in lower limb hemodynamics caused alteration of the phase structure of the cardiac cycle. The less marked increase in absolute duration of phase of isometric contraction and related derivative parameters indicate that the actual duration of the presphygmic interval during inflight LBNP diminishes, as compared to ground-based conditions. This is probably related to the increase in orthostatic influences, with greater increase in HR, in weightlessness with time. Probably, the more marked inflight increase in peripheral resistance during LBNP, which prevents considerable increase in duration of the phase of isometric contraction also plays some buffer role.

One of the possible explanations for the increased RPPW in the aorta is referable to constrictory changes in the arterial vascular bed in response to decline of usual circulating blood volume, when there is disruption of conformity of bed vessels to volume of blood it contains.

On the whole, tolerance of inflight LBNP tests remained at a rather high level. The more marked changes in parameters with LBNP did not present a clearcut relationship to flight duration. It can be assumed that these changes were due, to some extent, to dehydration of the body and decline in circulating blood volume.

#### Results of coronary tests

The magnitude of the load did not deviate on the average by more than +6%, although *in vivo* power of exercise exceeded the proper level by 100 kg·m/min or more. The averages for the entire flight period for HR during 5-min exercise as a rule were at about the same level in 4 cosmonauts (121-123/min), whereas lower values (85-111/min) were observed for FLE-1, FLE-2, FLE-3 and FLE-4. As compared to ground-based data, mean HR level for the entire load period from several (by 1 and 5%, respectively) in FLE-1 and CDR-2, whereas in FLE-3 and FLE-4, on the contrary, it dropped (by 10-14%). The changes in relative HR increases were in different directions: maximum relative increase increased in 7, 10% and 114% in 3 cosmonauts (CDR-1, B-1 and CDR-1 [sic]), whereas 5, 9% and 10% profitably, and decreased in 6 others and to the greatest extent in FLE-3 and FLE-4 (from 90 to 68-69%). Estimation of ratio of mean HR to maximal rate of exercise revealed that this parameter increased in the older astronauts in 2 cosmonauts (FLE-1 and FLE-2), i.e., chronotropic coupling was also better increased, whereas it either remained unchanged or diminished in the three astronauts.

In the vast majority of inflight tests, time for reaching a steady state and returning, generally, to 80 days, did not differ substantially from pre-flight data or was even shorter. The only exceptions were 2 tests on FLE-1 and 1 on FLE-2, where an observed extension of these periods.

During the period of daily ventilation in most inflight tests, absolute AP was lower than on the ground. Thus, minimal AP was an average of 4-17% lower, mean 7-15% lower, lowest 5-17% lower and pulsated AP 7-32% lower in most cosmonauts. In 5 of 20, venous and arterial pressure after inflight exercise had the equality below 1000 in the ground-based tests. On the

whole, the AP increment under the influence of the load was smaller in the flight tests than on earth.

The change in parameters of cardiac function, as compared to the preflight period, was manifested by a more marked decline of absolute values for duration of phases of isometric contraction and relaxation, as well as interphase coefficient, less significant decline in most cases of absolute duration of ejection period, more significant increase in absolute intrasystolic index and its ratio to nominal values, more marked decline of absolute mechanical systole, diastole and filling period. In 4 out of 6 cosmonauts, absolute rapid filling phase was shorter than preflight. And, while this parameter usually increased or did not change under the influence of the load, as a rule it decreased during flight.

The inherent distinction of hemodynamic changes during the ergometry test in flight was change in mechanism of formation of cardiac output. Thus, preflight increase in cardiac output in the period of early restitution was determined by two factors to approximately equal extents: increase in stroke volume and HR increment; stroke volume changed in a different direction (19% in the direction of increase and 12% in the direction of decrease) only in CDR-1.

Cardiac output increased in all of the tests, as it did preflight, more so than in the ground-based tests in the crew of the 1st mission and, as a rule, less so in FLE-2, FLE-3 and the crew of the 4th mission. In the rest of the cosmonauts, relative increment of cardiac output did not differ from the preflight values. Specific peripheral resistance decreased more than in preflight tests in FLE-1 and CDR-3, and less in CDR-2 and FLE-3. Another typical distinction was increase in both absolute and relative RPPW increment in the aorta under the effect of ergometry. While preflight RPPW in the 1st min after exercise (according to mean inflight values) was in the range of 772-920 cm/s in 7 cosmonauts, it rose during the flight to 890-1122 cm/s (or by 3-40%). At the same time, a more marked RPPW increment, in relation to base values, was found in the flight tests only in 3 cosmonauts (CDR-1, FLE-1 and CDR-3), whereas in the others, it either generally failed to differ much from ground-based values or was lower.

Thus, there was a tendency toward decline of relative increment of HR and absence in most cases of increase in HR/exercise ratio in the flight tests, as compared to preflight changes. In addition, we observed less marked AP increment, greater reduction of isometric phases of contraction and relaxation, mechanical systole, filling phases and less marked relative reduction of ejection period, formation of cardiac output chiefly at the expense of cardiac contractions, with relatively minimal changes in stroke volume, increase in RPPW in the aorta.

These studies revealed that the work performed by crew members of Salyut-6 during flight tests was associated with normotonic reactions of circuscardiotocogram and hemodynamic parameters, in which there was coordination and a parallel between changes in heart rate and blood pressure: faster pulse with concurrent rather marked increase in pulse amplitude due to elevation of systolic and moderate drop of diastolic AP (G. M. Kukolevskiy, 1968). One of the causes of minimal AP reaction, which was observed in a number of cases, could be that

the changes in systolic (lateral) blood pressure, determined by tachoscellography in response to exercise are much less manifested than changes in maximum AP obtained by auscultation (Yu. I. Kuznetsov, 1968). Another explanation could be the diminished venous return of blood to the heart chambers and decreased stroke volume due to reduced volume of actively circulating blood (V. G. Doroshev et al., 1974).

The "working in" period, when the heart rate reaches a steady state differed little inflight from preflight data in all of the cosmonauts, and as a rule it was observed in the 2d-3d min of pedaling. However, in the FLE-1, whose circulatory reaction was the most marked during the flight, no distinct moment of HR steady state was established, which probably reflected some degree of deconditioning.

Insufficient increase of venous influx, due both to decrease in total circulating blood volume (R. Johnson et al., 1977) and its deposition in arterioles of working muscles of the lower limbs probably play the leading role in the mechanism of functional cardiac reactions to ergometry. The inadequate venous influx to the heart causes relatively minor increase (or none at all) in stroke volume of the heart and formation of cardiac output primarily due to tachycardia. It can also be assumed that the assumed excessive volume of blood in the cardiopulmonary region and experimentally proven redistribution of blood in the cardiopulmonary region during exercise in the direction of increased pulmonary volume (C. Chapman et al., 1959; D. Harrison et al., 1963) could be instrumental in shifting some blood from the pulmonary region to vessels of working muscles of the lower extremities, particularly if we consider the possibility of existence of a zone of free extensibility of veins as a result of lowered transmural pressure (S. Mellander et al., 1968).

The physical load in itself activates the sympathetic nervous system (S. Marshall, J. Shepherd, 1972). The assumed partial shift of blood to the zone of tension in working muscles from the cardiopulmonary region leads to lower pressure in this region and, apparently, causes activation of the sympathetic nervous system (J. Shepherd, 1974). As a result of summation of these two factors in weightlessness, adrenergic influences may be more marked than during exercise on earth. For this reason, in weightlessness there can be enhancement of positive inotropic influences, which is probably what causes greater increase in force of cardiac contraction during ergometry and at the stage of early restitution (V. L. Karpman, 1965). It can be assumed that the more marked reduction of intervals of isometric contraction during the inflight tests is related to increased force of cardiac contraction under these conditions.

An insignificant decrease in ejection period in most cases is probably due to the fact that the positive chronotropic influence, which is instrumental in lengthening the mechanical systole and period of ejection, is buffered out to some extent at the stage of early restitution in weightlessness by venous return to the heart, due to elimination of tension in the walls of venous vessels of working and nonworking limbs (R. Bevegard, J. Shepherd, 1965) which is present during a physical load (in spite of dilatation of arterioles), as well as the influx of blood, which accumulated in them in greater quantities than on earth.

Thus, the functional tests performed during long-term spaceflights enabled us to demonstrate several inherent distinctions of hemodynamic reactions to loads. It was shown that, in long-term weightlessness, there is generally no manifestation of deconditioning of the cardiovascular system. At the same time, reactions to inflight functional tests with LBNP were more marked in some cases than on earth. With LBNP, we observed an increase in absolute HR, decline of minimal and mean dynamic blood pressure. The more drastic reduction of blood volume in the cardiopulmonary region, as compared to earth, evidently increases as a reflex activity of the vasomotor center, while the more marked reduction of stroke volume is compensated by an increase in HR and vascular tonus. The decline in volumetric load elicits less myocardial tension and reduces the force of cardiac contraction.

On the whole, the dynamics of parameters of the circulatory system during tests involving a physical load were indicative of absence during the flight of the typical signs of physical deconditioning of the cosmonauts. The cardiodynamic changes in these tests were apparently due to insufficient venous return of blood to the heart. This was indicated by alteration of formation of cardiac output, mainly at the expense of tachycardia, whereas there was significant decrease in increment of stroke volume during inflight tests under the influence of exercise.

Maintenance of physical conditioning at a proper level and absence of infections referable to inflight work and rest schedule improve significantly the defensive properties of the human body in relation to hydrostatic and physical loads.

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MATHEMATICAL ANALYSIS OF HEART RHYTHM IN ASSESSMENT OF DISTINCTIVE FEATURES  
IN ADAPTATION TO SPACEFLIGHT CONDITIONS

Moscow VESTNIK AKADEMII MEDITSINSKIKH NAUK SSSR in Russian No 4, Apr 84  
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[Article by R. M. Bayevskiy, G. A. Nikulina and I. G. Tazetdinov (Moscow)]

[Text] The First All-Union Symposium on Mathematical Methods of Heart Rhythm Analysis convened under the chairmanship of V. V. Parin in Moscow, 1966. V. V. Parin actively supported anything new in science and devoted particularly much attention to introduction to medicine of advances in electronics, mathematics and cybernetics. Mathematical analysis of cardiac rhythm as a method of evaluating regulatory and control systems in the integral organism gained particularly broad development in our country thanks to the initiative of V. V. Parin. By now, hundreds of works have been published in our country and abroad, which describe the use of mathematical (cybernetic) analysis of cardiac rhythm in experimental and applied physiology, clinical practice, space and aviation medicine, sports medicine and industrial physiology, engineering psychology and balneology. This method is one of the newest directions in physiology and pathology of circulation, which combines ideas of nervism traditional for the Russian physiological school with the modern informational, systems approach to investigation of control processes in a living organism.

Introduction of the new method to physiology and clinical practice immediately raises the question of normal range and signs of pathology. Most of the parameters in current use in physiology of circulation (pulse rate, arterial pressure, stroke volume and cardiac output) characterize the level of system function formed as a result of the activity of control mechanisms. There is not much variability in these parameters. Unlike them, mathematical characteristics of heart rhythm are referable to an entirely different class of parameters, which reflect the status of regulatory systems. In order to achieve the same end result, each organism exerts dissimilar efforts, depending on its functional reserve, adaptation capacities and reaction type. For this reason, variability of parameters characterizing the activity of regulatory systems is much greater than that of parameters reflecting the functioning level of different systems. For this reason, their normal range is considerably wider, while the limits of pathological changes are notable for great individuality. Experience shows that one should work out the standards of statistical-mathematical characteristics of heart rhythm to apply to each micropopulation of people, according to age, sex, physical conditioning, occupation, as well as season, time of day, etc.

The system for controlling heart rhythm can be arbitrarily conceived of in the form of two circuits, central and autonomic. Such a model is a substantial simplification of the real control system, which is notable for complex and diverse neurohormonal and humoral connections and has a multicircuit, hierarchic structure. Experimental and clinical data give us grounds to believe that the autonomic circuit is related to alteration of the functioning level of the sinus node in accordance with respiratory changes in delivery of blood to the cardiac chambers. In this circuit, changes in tonus of vagal nuclei are of basic significance. The circuit of autonomic regulation ultimately causes a change of the role of pacemaker from one sinus node cell to another. The central circuit of control is the source of corrective influences on the sinus node through the system of the autonomic circuit, and it provides for alteration of the body's functional systems in accordance with changes in environmental conditions; homeostatic regulation of interaction between different physiological systems in the body (intersystem level of regulation); equilibration of different elements of regulation within the different systems (intrasystem level of regulation).

Adaptive alteration of functional systems of the body, which is directed to change the levels of function of its elements, takes place by change in interaction of central and autonomic control mechanisms. In the presence of diverse extreme and subextreme factors, an increase in level of function of the body and its elements (systems) requires increasingly active intervention of central mechanisms in activity of autonomic ones. And, in spite of retention of homeostasis, adaptive equilibration of the body with the environment occurs as a result of increased tension of regulatory processes. An increase in tension of regulatory mechanisms is obtained both by intensification of activity of specific systems, for example, tonus of sympathetic nerves, and increased interaction between different elements of the functional system, involvement of new elements in the adaptation process, which is manifested, in particular, by activation of subcortical nerve centers.

Mathematical analysis of heart rhythm consists of measuring the duration of the dynamic series of cardiac intervals and processing the obtained digital array by means of various statistical mathematical methods (R. M. Bayevskiy, 1968, 1976, 1979; D. Zhemaytite, 1968; A. D. Voskresenskiy, M. D. Venttsel', 1964; V. I. Vorob'yev, 1978; G. A. Nikulina, 1974). Histogramic, autocorrelation and spectral analysis of cardiac intervals have also gained the widest use. The software for mathematical analysis of heart rhythm has been developed for high-power and average-power computers; hardware has been developed on the basis of using microcomputers and microprocessors. Of the wide diversity of statistical mathematical parameters described in the literature, we shall call attention to the tension index (TI) of regulatory systems proposed by G. I. Sidorenko (1973) and later by R. M. Bayevskiy (1974), as well as parameters characterizing the power of respiratory and slow waves of heart rhythm ( $S_0$  and  $S_g$ ). These parameters have found application in space medicine, which we shall be discussing below.

The TI is calculated from the parameters of the curve of distribution of cardiac intervals ( $TI = A_{Mo}/2 Mo \Delta X$ ) and takes into consideration the mode ( $Mo$ --most commonly encountered value for cardiac interval), mode amplitude ( $A_{Mo}$ --number of values corresponding to mode as percentage of total analyzed cardiac intervals)

and variation range ( $\Delta X$ --difference between maximum and minimum values for cardiac intervals). Since  $\Delta X$  reflects primarily the amplitude of respiratory fluctuations of heart rhythm related to activity of vagus nerve centers, while  $AM_0$  characterizes the activity of the sympathetic nervous system aimed at stabilizing fluctuations of these intervals,  $TI$  is an indicator of prevalence of central (sympathetic) influences over autonomic ones (parasympathetic). The functional level of the sinus node (value of  $1/2 M_0$ ) is also taken into consideration. The correlation between central and autonomic regulation can also be studied by means of spectral analysis of dynamic series of cardiac intervals. Here, determination is made of centralization index ( $S_0/S_g$ ). However, analysis of parameter  $S_0$  also has independent relevance, since it characterizes the overall activity of subcortical nerve centers.

Space medicine is one of the areas, in which mathematical analysis of heart rhythm has already been in use for 20 years. As far back as the first missions aboard Vostok and Voskhod spacecraft, analysis of dynamic series of cardiac intervals made it possible to demonstrate the phenomenon of "space arrhythmia" within the first hours and days of man's exposure to weightlessness (R. M. Bayevskiy, O. G. Gazenko, 1964; R. M. Bayevskiy; K. I. Zhukov, 1964). Speaking at the opening of the First All-Union Symposium on Mathematical Analysis of Heart Rhythm, V. V. Parin stated: "Why is it that expressly heart rhythm was the object of powerful impact by mathematical disciplines? A significant share of the 'blame' is put upon space medicine and space physiology, a new and rapidly developing area of knowledge." Heart rhythm is one of the physiological parameters that is the most accessible to recording, which is particularly important to cosmonautics, where the tasks of ongoing evaluation and forecasting the functional state of cosmonauts is a mandatory prerequisite for manned spaceflights. It is expressly in space medicine that extensive studies were conducted in recent years in order to determine the value and limits of using mathematical analysis of heart rhythm. Considerable advances have been made in the area of automation of heart rhythm processing.

Spaceflight conditions constitute a set of stress factors to which man is exposed continuously and for long periods of time. Adaptation to these conditions, particularly in weightlessness, is a complicated and still insufficiently investigated process that occurs in stages. In the course of adaptive reactions, there is formation of a new functional system, appearance of new connections between controlled and controlling elements of the body. Such alteration requires additional expenditure of energy and creates some tension in regulatory systems. The new level of functioning of the body, in particular its circulatory system, is determined by the functional reserve and degree of tension in regulatory systems (R. M. Bayevskiy, 1979). The higher the tension in regulatory systems and the lower the functional reserve, the higher the "cost of adaptation." Mathematical analysis is an effective method for measuring tension in regulatory systems. Under spaceflight conditions, the definition of functional reserve from the classical standpoint, as the difference between maximum achievable level of a specific function and the level of this function at physiological rest, is virtually unrealistic. Here, it is preferable to define functional reserve as the body's (system's) readiness or capacity to perform a given activity within a given time with minimal tension of regulatory mechanisms (R. M. Bayevskiy, 1979).

Let us examine the distinctions of the body's adaptive reactions during a long-term spaceflight. The main effects related to weightlessness are displacement of body fluids to the upper part of the body, which leads to changes in cardiovascular system function and fluid-electrolyte metabolism, as well as decline in energy expenditure, muscle tone and afferent impulsation (O. G. Gazeiko, 1962; Ye. A. Kovalenko, I. I. Kas'yan, 1982). However, a change in functional level of the main body systems is inhibited thanks to regular physical conditioning. There is, so to speak, a "fight" between two functional systems in the body: one that adjusts to the unique conditions of weightlessness and another, which preserves the functional structure inherent in an organism that has been well-conditioned on earth. In the opinion of N. P. Gurovskiy and A. D. Yegorov (1983), there is relative stabilization of adaptive reactions after 4-6 weeks in weightlessness. Such parameters as pulse rate, blood pressure, stroke volume and cardiac output change insignificantly (A. D. Yegorov et al., 1983; I. I. Kas'yan, 1983). However, in order to retain homeostasis of the main physiological systems, the body "pays" a certain "price," spends its functional reserves and tension arises in regulatory systems.

One of the approaches to evaluation of functional reserve and tension of regulatory systems is to study the circadian rhythm of physiological processes, in particular the statistical-mathematical parameters of heart rhythm. In essence, this means that cyclic processes in living systems can be defined as adaptation processes aimed at maintaining equilibrium both within the body and between the body and environment. For this reason, the amplitude of fluctuations can be viewed as an indicator of optimality of alteration of the biological system, reflecting its functional reserve. The degree of tension in regulatory systems (adaptation mechanisms) can be characterized by current and average levels of activity of the corresponding parts of the autonomic nervous system. In order to obtain the needed information, we used dynamic electrocardiography--continuous 24-h recording of ECG using a portable magnetic recorder (N. Holter, 1962). As we know, dynamic electrocardiography gained the widest use for examination of patients with ischemic heart disease and diverse rhythm disturbances. In space medicine, this method is more important for evaluation of adaptation capacities of the organism than for the study of traditional electrocardiographic features. Dynamic electrocardiography is used regularly during long-term missions, as well as before and after short- and long-term flights.

The methodological approach to analysis of a continuous 24-h digital array of values for duration of cardiac intervals (about 100,000) consists of calculating the basic statistic parameters for each 100 intervals, then these parameters are added for each hour, 6- or 8-h period and a full 24 h. Table 1 lists the 24-h dynamics of statistical characteristics of heart rhythm for a group of cosmonauts in the preflight period. A comparison of these data to the results of inflight studies (see Tables 2-4) shows that there are some changes, which reflect corresponding changes in autonomic homeostasis caused by the spaceflight factors.

The mean 24-h values for statistical characteristics of heart rhythm during four long-term missions aboard the Salyut-6 orbital station indicate that, in some cosmonauts--CDR-2, FLE-2, CDR-4 (CDR--commander, FLE--flight engineer)--after 4-5 months in spaceflight, there was intensification of activity of the

sympathetic part of the autonomic nervous system (increase in AMo, TI, decrease in  $\Delta X$ ), which could be evaluated as a state of functional stress. A more careful analysis of the results of tests on CDR-2 and FLE-2 in different periods of the day revealed that there was inflight alteration of autonomic homeostasis related to the structure of the circadian cycle. Thus, in the CDR maximum activity of adrenergic mechanisms of regulation shifted to the night hours, whereas in the FLE their significant activation was observed in the evening. There was significant change in current and 24-h mean values of statistical-mathematical parameters of heart rhythm, indicating a shift of autonomic balance in the direction of significant intensification of activity of the sympathetic branch of the autonomic system. However, the amplitude of 24-h fluctuations of the parameters showed virtually no change, which is indicative of retention of adequate adaptation capacities.

Table 1. 24-Hour dynamics of statistical characteristics of heart rhythm in group of cosmonauts in preflight period ( $M \pm m$ )

| Time of day,<br>hours | Mo, s     | AMo, %    | $\Delta X$ , s | TI      |
|-----------------------|-----------|-----------|----------------|---------|
| 8                     | 0.80±0.04 | 41.2±4.6  | 0.29±0.04      | 129±36  |
| 9                     | 0.80±0.04 | 44.0±3.2  | 0.23±0.02      | 140±31  |
| 10                    | 0.89±0.07 | 47.3±4.2  | 0.29±0.03      | 132±38  |
| 11                    | 0.90±0.04 | 36.0±4.2  | 0.32±0.03      | 108±52  |
| 12                    | 0.95±0.07 | 37.4±5.03 | 0.33±0.03      | 88±31   |
| 13                    | 0.83±0.06 | 38.0±4.4  | 0.27±0.03      | 124±34  |
| 14                    | 0.85±0.03 | 40.2±3.8  | 0.26±0.05      | 163±53  |
| 15                    | 0.71±0.03 | 46.5±13.9 | 0.25±0.04      | 168±41  |
| 16                    | 0.75±0.03 | 40.0±3.6  | 0.26±0.03      | 128±51  |
| 17                    | 0.74±0.04 | 39.8±3.6  | 0.23±0.02      | 151±41  |
| 18                    | 0.80±0.03 | 41.8±4.6  | 0.23±0.03      | 177±53  |
| 19                    | 0.80±0.03 | 41.0±3.1  | 0.23±0.02      | 131±17  |
| 20                    | 0.82±0.04 | 40.2±4.0  | 0.27±0.02      | 151±41  |
| 21                    | 0.78±0.04 | 44.7±4.4  | 0.24±0.03      | 182±53  |
| 22                    | 0.82±0.04 | 36.5±3.8  | 0.29±0.04      | 109±41  |
| 23                    | 0.88±0.04 | 44.6±4.5  | 0.24±0.04      | 154±44  |
| 24                    | 0.93±0.06 | 43.8±5.0  | 0.30±0.05      | 213±115 |
| 1                     | 0.99±0.06 | 44.5±3.2  | 0.29±0.04      | 87±17   |
| 2                     | 0.99±0.06 | 42.4±4.2  | 0.30±0.05      | 85±24   |
| 3                     | 1.06±0.04 | 41.8±4.2  | 0.27±0.03      | 81±15   |
| 4                     | 1.02±0.05 | 36.0±3.3  | 0.44±0.06      | 46±9    |
| 5                     | 1.03±0.04 | 38.8±3.6  | 0.33±0.05      | 78±22   |
| 6                     | 1.02±0.05 | 42.3±4.1  | 0.34±0.05      | 97±3    |
| 7                     | 0.96±0.04 | 39.6±2.3  | 0.32±0.02      | 68±8    |
| 8-15                  | 0.84±0.02 | 41.3±1.4  | 0.28±0.01      | 132±15  |
| 16-23                 | 0.79±0.01 | 40.5±1.5  | 0.25±0.01      | 131±17  |
| 24-7                  | 0.99±0.01 | 41.1±0.9  | 0.32±0.02      | 96±18   |
| 24-h mean             | 0.88±0.02 | 39.4±1.6  | 0.28±0.01      | 120±7   |

The value of analysis of hourly mathematical-statistical characteristics of heart rhythm is demonstrated in Table 4, which lists the results of preflight and postflight tests on crew members of Soyuz T-8 spacecraft, which included a woman cosmonaut, S. Ye. Savitskaya (KI). It lists changes in pulse rate and TI in the evening (they landed at 1830 hours). These data indicate that, depending on the type of autonomic regulation, some fluctuations are observed postflight in the dynamic series of parameters. Thus, in the CDR, who was

Table 2. Statistical-mathematical parameters of heart rhythm of CDR-2 and FLE-2 at different times of day according to dynamic electrocardiography data

| Time<br>of<br>day,<br>hours | CDR-2     |     |      |                      |      |    | FLE-2     |      |     |                     |    |     |      |     |      |
|-----------------------------|-----------|-----|------|----------------------|------|----|-----------|------|-----|---------------------|----|-----|------|-----|------|
|                             | preflight |     |      | 120-121st flight day |      |    | preflight |      |     | 121-122d flight day |    |     |      |     |      |
|                             | PR        | TI  | Mo   | AMO                  | ΔX   | PR | TI        | Mo   | AMO | ΔX                  | PR | TI  | Mo   | AMO | ΔX   |
| 7-12                        | 71        | 98  | 0.85 | 39                   | 0.28 | 82 | 148       | 0.74 | 38  | 0.24                | 73 | 166 | 1.14 | 52  | 0.32 |
| 13-18                       | 76        | 167 | 0.80 | 49                   | 0.19 | 94 | 376       | 0.64 | 57  | 0.18                | 70 | 126 | 0.9  | 49  | 0.25 |
| 19-24                       | 72        | 192 | 0.86 | 50                   | 0.22 | 88 | 230       | 0.68 | 47  | 0.18                | 61 | 61  | 1.0  | 37  | 0.37 |
| 1-6                         | 59        | 53  | 1.0  | 37                   | 0.33 | 93 | 406       | 0.65 | 66  | 0.12                | 46 | 49  | 0.3  | 36  | 0.49 |

Note: Here and in Tables 3 and 4, PR is pulse rate per min.

characterized by a moderate sympathotonic level of regulation (mean pulse rate  $71.0 \pm 1.8$ /min, TI  $136 \pm 13$ ), there was a distinct shift in the direction of prevalence of sympathetic branch of the autonomic nervous system (pulse rate  $79.0 \pm 6.5$ /min, TI  $210 \pm 47$ ) with some increase in amplitude of fluctuations of both parameters. In the FLE, preflight autonomic homeostasis was characterized by moderate vagotonia (pulse rate  $56.8 \pm 1.2$ /min, TI  $71 \pm 6$ ). Postflight, we observed normotonic regulation with insignificant increase in amplitude of fluctuation of parameters (pulse rate  $59.0 \pm 9$ /min, TI  $94 \pm 9$ ). Preflight, there was the vagotonic type of regulation in the KI (pulse rate  $57.2 \pm 2.7$ /min, TI  $44 \pm 4$ ), whereas postflight we observed a marked shift of autonomic balance in the direction of prevalence of the sympathetic branch of the autonomic nervous system (pulse rate  $96.2 \pm 2.7$ /min, TI  $369 \pm 31$ ). There was no increase in amplitude of fluctuations of TI, whereas for pulse rate it diminished somewhat. Even on the 3d postflight day, the KI retained a distinct sympathotonic type of heart rhythm regulation (pulse rate  $79.4 \pm 4.1$ /min, TI  $177 \pm 38$ ) with increased amplitude of fluctuations of parameter values. According to the submitted data, the distinction of the female reaction to factors involved in a 7-day spaceflight was heightened reactivity, as manifested by significant and persistent shift of autonomic homeostasis in the direction of prevalence of sympathotonic regulation, in the presence of preflight vagotonia. However, there was no decline of the body's adaptive capacities.

The most important element of the system of preventing the adverse effects of weightlessness is, as we know, physical exercise to maintain conditioning of the most important systems of the body and stimulate certain groups of receptors (O. G. Gazenko, A. A. Gyurdzhian, 1967; P. V. Vasil'yev, 1974; I. D. Pestov, Z. D. Geratevol', 1975; N. N. Gurovskiy, A. D. Yegorov, 1983). The methods for physical exercise aboard the orbital station include gradual and constant increase in volume and intensity of loads in order to gain the capacity for

performing high-power physical work (V. A. Tishler, V. I. Stepansov, 1983). However, reliable monitoring of state of physical conditioning is required when building up energy expenditures during physical exercise, so as not to overdo and, at the same time, assure adequate physical work capacity in the cosmonauts by the time the flight is terminated.

Table 3. Mean 24-h values for parameters of mathematical analysis of heart rhythm according to results of dynamic electrocardiography (M:m)

| Crew member | Time of study    | PR       | AMo, %   | $\Delta X$ , s | TI       |
|-------------|------------------|----------|----------|----------------|----------|
| CDR-2       | Preflight        | 69.0±2.5 | 43.3±2.7 | 0.25±0.02      | 1.31±2.3 |
|             | 120th flight day | 89.0±2.0 | 50.1±4.1 | 0.18±0.01      | 230±36   |
| FLE-2       | Preflight        | 62.3±3.1 | 36.7±2.8 | 0.33±0.03      | 92±22    |
|             | 121st flight day | 71.3±4.5 | 60.4±4.1 | 0.15±0.01      | 339±80   |
| CDR-3       | Preflight        | 67.0±7.8 | 37.0±7.8 | 0.34±0.02      | 90±13    |
|             | 155th flight day | 64.0±4.9 | 43.0±1.9 | 0.35±0.02      | 69±8     |
| FLE-3       | Preflight        | 60.5±2.3 | 39.0±2.4 | 0.29±0.03      | 91±14    |
|             | 156th flight day | 67.0±2.7 | 40.0±2.7 | 0.29±0.01      | 104±17   |
| CDR-4       | Preflight        | 68.1±2.8 | 45.5±6.4 | 0.29±0.02      | 94±17    |
|             | 103d flight day  | 78.3±2.9 | 36.3±2.3 | 0.24±0.01      | 117±21   |
| FLE-4       | 155th flight day | 71.4±2.7 | 46.2±3.3 | 0.20±0.03      | 175±33   |
|             | Preflight        | 60.5±2.3 | 39.0±2.3 | 0.29±0.03      | 91±14    |
|             | 104th flight day | 64.9±2.4 | 39.2±2.3 | 0.27±0.02      | 90±12    |

Table 4. Dynamics of pulse rate and TI of regulatory systems in crew of Soyuz T-8 from 1900 to 2400 hours during preflight examination and first hours of recovery period

| Crew member               | Parameter | Time of day, hours |             |             |             |             |            | Mean for period |
|---------------------------|-----------|--------------------|-------------|-------------|-------------|-------------|------------|-----------------|
|                           |           | 19                 | 20          | 21          | 22          | 23          | 24         |                 |
| Preflight                 |           |                    |             |             |             |             |            |                 |
| CDR                       | PR        | —                  | 62.5±1.67   | 73.5±3.38   | 77.1±0.78   | 72.0±0.85   | 68.6±0.80  | 70.93±1.85      |
| FLE                       | PR        | —                  | 104.0±16.3  | 107.0±24.45 | 143.0±17.87 | 159.0±10.7  | 129.0±9.32 | 140.4±13.63     |
|                           | TI        | 57.3±0.47          | 56.5±0.53   | 57.1±1.18   | 57.4±0.8    | 62.4±0.86   | 55.0±0.12  | 56.28±1.22      |
| KI                        | PR        | 53.0±4.63          | 56.0±4.16   | 50.0±3.83   | 83.0±7.04   | 77.0±6.76   | 98.0±10.44 | 71.42±6.45      |
|                           | TI        | 61.0±6.1           | 62.0±4.2    | 61.0±7.0    | 46.0±5.0    | 54.0±5.2    | 66.0±5.8   | 57.16±2.69      |
|                           |           | 45.92±3.12         | 40.33±2.24  | 50.61±6.89  | 62.0±6.94   | 42.22±4.28  | 28.0±3.8   | 44.84±4.21      |
| Postflight                |           |                    |             |             |             |             |            |                 |
| CDR                       | PR        | —                  | 98.9±2.6    | 56.2±0.81   | 83.6±1.2    | 85.9±0.84   | 70.5±2.49  | 79.02±6.5       |
| FLE                       | PR        | —                  | 273.0±56.19 | 115.0±21.55 | 171.0±65.7  | 387.0±54.57 | 108.0±16.7 | 210±47.4        |
|                           | TI        | 66.0±1.12          | 69.7±1.64   | 61.7±1.53   | 72.0±1.02   | 73.7±1.82   | 70.5±1.97  | 59.08±9.22      |
| KI                        | PR        | 67.0±6.28          | 122.0±18.22 | 66.0±6.60   | 94.0±6.40   | 96.0±8.43   | 120.0±7.99 | 94.16±9.09      |
|                           | TI        | 97.1±3.2           | 105.8±2.52  | 88.0±0.47   | 98.7±1.77   | 95.2±0.9    | 86.5±5.3   | 95.21±2.66      |
|                           |           | 336.0±87.1         | 470.0±58.4  | 253.0±23.2  | 424±60.8    | 432.0±54.9  | 304.0±84.8 | 369.8±31.6      |
| 3d day of recovery period |           |                    |             |             |             |             |            |                 |
| KI                        | PR        | 86.2±12.3          | 65.2±2.7    | 69.2±2.6    | 86.2±2.85   | 93.2±12.0   | 79.2±12.2  | 79.4±4.11       |
|                           | TI        | 263.0±31.2         | 85.0±62.3   | 78.0±32.9   | 225.0±22.3  | 306.0±39.2  | 107.0±62.2 | 177.3±38.08     |

Physical conditioning, as the potential capacity of the body to effectively adapt to presented loads is attributable to development of certain changes on the structural, metabolic and energy levels. Achievement of long-term adaptation to physical loads is related to intensification of synthesis of nucleic acids and protein in cells and tissues (F. Z. Meyerson, 1981), so that "the price of

"adaptation" is an important indicator of physical conditioning. In order to determine the "price of adpatation," we need to know the correlation between functional reserve and extent of regulatory system tension. As applied to the study of physical conditioning, functional reserve can be characterized as the capacity to perform specific work at a given level of functioning of the

principal body systems, in particular the circulatory system. The PWC<sub>170</sub> (power of work on cycle ergometer with pulse rate of 170/min) is a very adequate indicator of functional reserve during physical exercise loads. At the present time, this is a commonly used parameter (K. M. Smirnov, 1970; V. L. Karpman et al., 1974). Tension in regulatory systems can be characterized by parameters of mathematical analysis of heart rhythm during exercise loads. The lower the tension of regulatory systems and the greater the functional reserve, the higher the physical conditioning.

Table 5.  
Mean flight values of PWC<sub>170</sub>, TI and S<sub>0</sub> during graded exercise test for crew members who participated in long-term missions aboard Salyut orbital stations (M±m)

| No | PWC <sub>170</sub> , kg·m/mm | TI       | S <sub>0</sub> |
|----|------------------------------|----------|----------------|
| 1  | 1445±27                      | 540±73   | 0.16±0.02      |
| 2  | 1428±42                      | 569±93   | 0.13±0.02      |
| 3  | 1225±14                      | 1505±354 | 0.20±0.03      |
| 4  | 1129±46                      | 1558±250 | 0.21±0.04      |
| 5  | 1090±24                      | 1659±219 | 0.42±0.03      |
| 6  | 1069±19                      | 1341±210 | 0.23±0.04      |
| 7  | 1064±32                      | 2690±317 | 0.24±0.02      |
| 8  | 1041±21                      | 2316±205 | 0.30±0.01      |
| 9  | 953±8                        | 2425±185 | 0.08±0.02      |
| 10 | 902±15                       | 3150±305 | 0.05±0.02      |

load test, who had participated in missions lasting at least 3 months. The results are arranged in order of diminishing values of PWC<sub>170</sub>. The corresponding values for TI indicate that there is a high negative correlation ( $r = -0.90$ ) between PWC<sub>170</sub> and TI. The existence of a wide range of changes in these parameters raises the question of criteria for estimating the "price of adaptation" of the body to the physical load. It can be answered on the basis of analysis of parameter S<sub>0</sub> (power of slow waves of cardiac rhythm). According to preflight findings, the values of this parameter are in the range of 0.176±0.052 at rest and 0.236±0.033 during exercise. Consequently, when there is a high level of physical work capacity (PWC<sub>170</sub> > 1400 kg·m/min), the values of S<sub>0</sub> during exercise are in the range of preflight levels at rest. With moderate physical work capacity (PWC<sub>170</sub> > 1000 kg·m/min), S<sub>0</sub> is in the range of preflight values during exercise. With low physical capacity (PWC<sub>170</sub> < 1000 kg·m/min), S<sub>0</sub> is below the preflight value at rest. Since the power of slow waves of cardiac rhythm reflects the activity of vasomotor centers, centers of heat regulation and other subcortical centers (B. Sajers, 1973; A. D. Voskresenskiy; M. D. Venttsel', 1964), the decline in values of S<sub>0</sub> during exercise can be interpreted as depression of activity of the corresponding nerve centers. Hence, the regulatory mechanisms called upon to participate in energetic and metabolic support of tissues and organs during exercise are in a state of inhibition. This could be due to their depletion (asthenization, deconditioning) or depression of their activity by overlying levels of the control system.

Thus, evaluation and prediction of physical condition of crew members can be done on the basis of comparing physical work capacity to parameters of mathematical analysis of cardiac rhythm. Rise in values of TI during exercise, combined with a decline of S<sub>0</sub>, is a criterion of worsening of physical conditioning. This

indicates that there is development of asthenization of regulatory mechanisms, since increased activity of adrenergic mechanisms in response to the stress of the physical load is not obtained by appropriate activation of subcortical nerve centers. Evidently, in this case there is no change from a brief adaptive effect to long-term adaptation.

In conclusion, it can be noted that mathematical analysis of heart rhythm is one of the important and promising methods in space medicine for evaluating and forecasting the functional state of cosmonauts and their capacity to adapt to complicated and unusual spaceflight conditions.

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## MECHANISMS OF OSTEODYSTROPHY IN WEIGHTLESSNESS

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[Text] Man's successful exploration of space has raised for physicians and biologists an extensive range of problems, the most important of which are developing measures to prevent adverse effects resulting from prolonged sojourns under weightless conditions. Among the various pathophysiological effects of weightlessness, even during the first years of manned spaceflight attention was drawn to the increased body losses of calcium, phosphorus and other elements, and also to the lowered content of minerals in the bones, as accessible to study by the modern methods of X-ray photometry and direct photon absorptiometry [33, 34]. It was suggested that as a result of the decrease in mechanical loads on the locomotor system there would be progressive loss of the bony substance and a loss of strength in skeletal bone [17, 32].

It has been shown that under conditions of bed rest changes take place in the human body similar to those observed in spaceflight. In particular, there is loss of minerals leading to rarefaction of bone mass, which is classified as osteoporosis of disuse [31, 35]. Thus, in medicine a scientific avenue has gradually taken shape for investigating the pathogenic effect of actual and modeled weightlessness on bone mineralization. Initially research was of a descriptive and phenomenological nature. It was shown that calcium and phosphorus losses vary widely on an individual basis and, moreover, depend on the duration of weightlessness. Taking into consideration the urgency of work on these problems, in 1967, at the suggestion of academician N.A. Fedorov of the USSR Academy of Medical Sciences, we embarked on an experimental study of the mechanisms involved in the development of osteodystrophy occurring under conditions of prolonged hypokinesia and weightlessness. At that time the most widely used method for modeling some of the effects of weightlessness was to create prolonged restriction of motor activity in animals with the aid of restricted cages designed so that the animals were not prevented from taking water and food, and in such a way that their hygiene requirements could be attended to on a daily basis.

Using this model in rats, rabbits and dogs, we studied the nature of the shifts in mineral and protein metabolism and the bone structure, and also the pathogenetic mechanisms of these disorders during the process of hypokinesia of varying duration. In addition, a study was made of the odontomaxillary system, which in prolonged restriction of motor activity carries out its normal function and reacts to the general dystrophic shifts in the skeleton with which it is linked through the common mechanisms of metabolic regulation. Data obtained as the result of these studies served as the basis for a study of the feasibility of reducing the degree of the disorders occurring in bone tissue by the use of a pharmacological agent, namely calcitonin, and also by a physical method, namely adaptation to an artificial, transient gaseous atmosphere deficient in oxygen and with excess carbon dioxide. Studies on the effect of hypokinesia on mineralized tissue constituted stage I of this work [1].

However, when modeling weightlessness only by restricting motor activity with the aid of restricted cages, the support function of the extremities is still retained, that is, the force load on the osteoarticular apparatus. Accordingly, in stage II an experimental model of hypokinesia and hypodynamia achieved by removing the support function by amputation of the extremities below the knee was used to reproduce the effects of weightlessness as applicable to the skeletal system. Lack of functional load on the skeleton also occurs in man under conditions of prolonged bed rest. Therefore, in stage II of the work a study was made of bone tissue taken from individuals undergoing strict bed rest for various diseases and from individuals who had died from sudden complications. Stage III of the research consisted of an analysis of the restructuring of bone tissue and its biophysical characteristics in animals (rats and tortoises) that had experienced spaceflight aboard artificial Earth satellites.

#### 1. The Effect of Hypokinesia with Retention of the Support Function of the Extremities on Bone Tissue.

Under conditions of hypokinesia of varying duration (up to 140 days) a slowdown has been observed in body weight increases in rats and a reduction of skeletal mass compared with controls [4, 10]. Restricted movement causes a reduced content of bony substance in the substantia spongiosa ossium, which is explained by the slowed formation of bone tissue, allowing for the minor changes in the amount of bone fragments studied. Retention of the structure of the cartilaginous epiphyseal zone of growth in the bone in young animals makes these changes reversible. In rats the density of the cortical layer of the diaphysis increases in hypokinesia, and this is accompanied by an increase in its mineral saturation and also of the microstructures in the subperiostal, intermediary and subendosteal zones [10]. This is explained by the suspension of formation of new, poorly mineralized tissue and a relative increase in the content of previously existing bony tissue having a higher content of mineral salts.

Results from a study of the effect of prolonged hypokinesia on bone tissue in rats and rabbits have been quite complicated to interpret since they were growing animals, and bone changes caused by the hypokinesia were associated

both with a slowdown in skeletal growth, probably caused by stress, and by the actual restriction of motor activity. Accordingly, studies were also conducted in adult dogs. It was established that restriction of motor activity in the dogs for periods of 30 to 180 days did not lead to change in the degree of mineral saturation anywhere in the thickness of the cortical layer of the diaphyses of the long bones. A tendency to minor increase was observed in the indexes for mineral saturation in the bony microstructures in the zones of the cortical layer of long support bones as the result of relative dominance of the number of highly mineralized osteons over newly formed osteons in the early stage of mineralization [9]. Similar changes in mineralization of the microstructures in bony tissue have been seen in puppies after a 60-day period of hypokinesia [18]. By comparing the findings obtained in experiments in rats and dogs it can be seen that increased degree of mineral saturation in the microstructures as the result of restricted motor activity with retention of the support function of the extremities is more marked the lower the baseline level for this index; and this, in turn, depends on the rate of restructuring in bone tissue. The more rapidly the bony structures are restructured the lower their average degree of mineral saturation, which also explains the more significant increase in the indexes for mineral saturation of bone tissue in rats in hypokinesia than in puppies and dogs. This effect is a manifestation of suppression of the rate of renewal of phosphorous and calcium salts in the mineral phase of bone, which we established by a radioisotope study [1]. Changes in the mineral component in hypokinesia are associated with disorders in the restructuring of bone tissue. Generalizing the results of research done along this avenue [1] it can be concluded that under conditions of prolonged hypokinesia in rats, rabbits and dogs increased resorption of bone tissue does not occur, that is, osteoporosis in the conventional sense does not develop. Only in experiments with puppies did extensive sites of resorption appear after a 2-month period of hypokinesia, mainly along the side of the vascular grooves in the presence of a large number of multinucleate osteoclasts [18]. Changes in the long bones of growing animals in prolonged restriction of movement are classified as true bone atrophy characterized by hypostosis--a decrease in the external diameter of the bone. We concluded that as a result of prolonged hypokinesia with retention of the support function of the extremities in animals a slowdown occurs in osteogenesis and that this mechanism lies at the basis of rarefaction of the spongy tissue and zones of muscle attachment and the slowdown in the development of the cortical layer of the diaphysis.

Changes in the bones of animals in hypokinesia created with the aid of restricted cages are not accompanied by abnormalities in the content of calcium and phosphorus--the main elements in the mineral substance of bone tissue [12,15]. The absence of changes in the bone calcium content, despite the significant increase in its expression in animals in hypokinesia [29, 30] is explained by the fact that the slowdown in bone restructuring entails a decrease in the total mass of the skeleton without disruption of the crystalline structure of the mineral substance. The main reason for the increased calcium expression in rabbits is suppression of the process of calcium utilization in bone tissue [2, 7] as a result of the slowdown in osteogenesis.

In a long-term animal experiment (rats, rabbits and canine pups) dystrophic changes were also found in the odontomaxillary system, particularly in the periodontal tissues., and also a slowdown in eruption of the teeth; which serves as a manifestation of generalized metabolic disorders in immobilized animals [13, 16], probably resulting from the impairment of afferent signals and energy use for muscular work against a background of a stress reaction developing in response to the change in ecological conditions.

The general patterns established in impairment of the osseous system in hypokinesia served as a basis for developing prophylaxis for these disorders. Calcitonin used for this purpose exerts a positive effect on the main parameters of mineral and protein metabolism in bone tissues in immobilized animals [2, 7, 8]. The decreased calcium loss with excretion under the effect of calcitonin confirms the advisability of using the hormone to prevent bone changes in prolonged restriction of motor activity [29, 30]. For this purpose, it is better to combine the calcitonin with a drug possessing an anabolic action, as for example, retabolil [proprietary name for a Hungarian-made anabolic steroid--ed][13]. However, in hypokinesia these pharmacological preparations do not exert any normalizing effect on skeletal growth.

Comparative data are available on the effect of an artificial, transient gaseous medium on mineralized tissue in rats under conditions of normal and restricted motor activity [3, 5, 6]. Proceeding from these data it can be concluded that intermittent, gradually increasing hypoxia corresponding to an altitude of 7,000 meters, and also hypercapnia with a normal oxygen content, potentiates the degree of bone changes in hypokinesia. Slow adaptation to an "altitude" of 5,000 meters with the addition of 3-5% carbon dioxide in an artificial gaseous medium results in a decrease in the degree of impairment of calcium and protein metabolism in mineralized tissue under conditions of prolonged restriction of motor activity. It is probable that this effect reflects an enhancement of nonspecific resistance under the effect of adaptation to the oxygen deficiency.

The experiments that have been conducted have not only extended our ideas about the mechanism of bone changes in prolonged restriction of motor activity but have also indicated the feasibility of controlling these changes with the aid of pharmacological and physical methods. The hypokinetic effects reviewed here resulted from the effect of modeling only of restricted motor activity with retention of the support function of the extremities. In actual conditions in weightlessness the main factor is the reduction in force loads on the supportive skeleton, that is, hypodynamia. With regard to the amount of movement, an increase in the size of space vehicle makes it possible to carry out a sufficiently large amount of movements.

## II. The Effect of Hypodynamia on Bone Tissue.

Unilateral exarticulation at the knee has been carried in experimental studies on rats and as a result the femur of the amputated limb was not subject to force load [23].

It has been established that the absence of the support function of the extremity causes a decrease in density, ash content and mineral saturation in bone tissue, along with a decrease in its strength properties. Hypokinesia with retention of the support function of the extremities, in contrast to hypodynamia, leads to an increase in the indexes characterizing mechanical properties, probably the result of the balance between the slowdown in osteogenesis and bone destruction. However, under conditions of hypodynamia, bone adaptation to the new dynamic and kinetic conditions results in disruption of this balance, with tissue resorption dominating over tissue formation, that is, depriving the bones of the function of opposing terrestrial gravitation leads to the development of osteoporosis. The main factor here is hypodynamia and not the surgical intervention, since the creation of a static load on the femurs by means of bilateral exarticulation at the knees resulted in less significant rarefaction of bone tissue. The findings from this work showed that in order to prevent osteoporosis when the support function is absent it is necessary not only to eliminate the hypokinesia but also to create conditions of static load on the extremities. One drawback in the model of femoral hypodynamia obtained by exarticulation at the knee is the development of an inflammatory process in the field of the distal epiphysis; and because of this, significant rarefaction of the bone tissue occurred. Therefore, in later studies we used the model of amputation in the upper third of the lower leg, which made it possible to retain the integrity of the knee joint and hence of the distal epiphysis. This experiment was conducted in dogs in experiments lasting 90 days and 345 days [14, 27].

The utilization of a comprehensive methodological approach in this experiment made it possible to reveal a number of new patterns in the mechanism of osteodystrophy in prolonged absence of the support function of the extremities. The osteoporosis that develops is characterized not only by the quantitative changes in the bone tissue, seen in the rarefaction of its mass, but also by qualitative shifts. This is expressed in an altered relationship between osteons possessing different degrees of mineralization. The greater mineralization of mature osteons can be explained by the fact that they were in existence before the creation of the nonsupport situation, were retained through the end of the experiment and, possibly, were further mineralized. Another feature of the bone tissue in the nonsupported extremity is the increase in the number of poorly mineralized microstructures and a decrease in the mean value for their density at isolated parts of the bone in a 345-day observation. It is possible that these microstructures, formed during the period when the extremity is nonsupported, possess a retarded ability for mineralization. Accordingly, the relationship between the osteons in the bone changes in favor of immature microstructures, and this is expressed in reduced mineralization of the bone tissue and a lower mean value for the microhardness indexes.

The findings from the hypodynamia experiments make it possible to suggest that in the mechanism of change in the mineral component of bone tissue and the restructuring of the bone tissue when the extremity is nonsupported, a major role is played the sharp drop in the afferent signals from the bone, by which there is no trophic reflex nor any piezo effect created by deformation of the bone during periodic load.

The level of bone mass loss in the *substantia spongiosa ossium* in the femurs of these dogs virtually stabilizes by the third month of hypodynamia, reaching an average of 33-38% with individual variations from 24% to 46%, varying in inverse proportion to the initial density of the bone structure [28]. In the compact substance the processes of atrophy occur significantly later than in the spongy tissue: after 3 months only the initial signs of bone tissue resorption are found on the side of the endosteum, along with resorption cavities within the cortical layer. Atrophy of the compact bone reaches significant proportions only by the end of the 345-day period. These changes are accompanied by reduced calcium concentration in the mineral substance, with normal phosphorus content and increasing potassium content. The strength and microhardness of the spongy and compact substance decrease. Here, the strength of the compact substance is largely determined by the chemical composition of the mineral component, while that of the spongy tissue is determined mainly by the degree of osteoporosis [27].

Reproduction of hypokinesia and hypodynamia in animals deprived of the support function of the extremities simulates only to a degree the actual conditions, since in this form of modeling there is no restructuring of the neurohumoral systems that occurs, for example, in man during prolonged bed rest or under weightless conditions. It has still not been possible to create an unsupported body position for animals under laboratory conditions. Accordingly it is important to obtain comparative data from experiments involving a nonsupported position for the extremities in animals and in studies involving prolonged bed rest in human subjects. In this connection a study was made of some of the biophysical characteristics of vertebrae and the calcaneus in human subjects who had died following hypodynamia from sudden complications [11, 25]. As the result of hypodynamia lasting 20-40 days, the calcium content dropped an average 5% in the human vertebrae while the potassium and sodium levels rose against a background of retention of normal phosphorus and magnesium contents. The absence of similar changes in the calcaneus when the skeleton was no longer under load is explained by the less marked nature of the metabolic activity of its microstructure compared with the vertebrae.

Attention is drawn to data indicating that the magnitude of mineral saturation in human vertebrae following prolonged bed rest corresponded to the normal while strength decreased in quite short periods as the result of the change in the chemical composition of the mineral substance, mainly the decreased calcium content. It is possible that when no load is placed on the axial skeleton there is partial restructuring of the spongy structures of the vertebra and formation of bone tissue with defective hydroxyapatite crystals, in whose structure the calcium atoms are partially replaced by other ions, namely of sodium and potassium. The reduced strength of vertebrae found in human subjects following hypodynamia is probably explained by a decrease in the rigidity of the crystal itself, and also its adhesion with the organic component. Since in all individuals kept in a bed-rest regime there were unidirectional changes in the vertebrae, they were regarded not as a sequela of somatic disease but mainly the result of absence of load on the skeleton.

Comparing the data cited here with results from studies of the nonsupported extremity in dogs, note should be made of the basic similarity of the changes

in the main parameters characterizing the bone tissue. These data make it possible to regard the creation of the nonsupport situation for the extremities in animals as an adequate model for studying the pathogenesis of bone changes in hypodynamia in man. Moreover, hypodynamia in human subjects, resulting from prolonged bed rest, and also absence of the limb function, can be used as a model that simulates some of the effects of weightlessness, in particular the absence of weight load on the locomotor apparatus.

### III. The Effect of Weightlessness on the Skeleton.

In this section we generalize findings published mostly elsewhere from experiments in rats that had undergone 19-22-day spaceflights aboard artificial Earth satellites of the "Cosmos" series, and in control animals kept on Earth in regular cages simulating the conditions in which experimental animals were kept aboard the satellite, except for weightlessness [1, 19, 20, 24, 28]. Experimental animals were sacrificed several hours after the completion of the flight, and also after a period of rehabilitation lasting 6 and 25-29 days. In accordance with the tasks set, bone material was processed using various methods that reflect quantitatively the density of structural composition in the bony substance, the degree of its mineralization, the concentration of chemical elements in the mineral component, the histological structure of the bone and so forth.

As a result of the effect of spaceflight factors, in rats mass increase in the bones of the extremities is retarded primarily through the spongy substance. Shrinking has also been noted in the cortical layer of the bone in the perosteum, indicating a slowdown in appositional growth in the bone, that is, the function of osteogenesis. As a result of shrinking primarily of the lateral portions of bone larger in size than the anteroposterior portions in cross section, the cross sectional shape of the bone was altered from ellipsoid to circular. The density and degree of mineral saturation also substantially decreased in the spongy structures, namely the distal epiphysis and the head of the femur; the development of osteoporosis took place with retention of the earlier mineralization of the bony substance in these fragments. Cortical changes were insignificant: osteoporosis did not develop and the degree of mineralization in the organic matrix was unaltered. At the same time a study of the composition of the mineral substance in the head of the femur showed that after a 6-day readaptation the calcium was low and was normalized only after 29 days under terrestrial conditions. It is probable that under weightless conditions there is retardation in the formation of the bony substance and the process of its maturation is slowed down. However, the development of osteoporosis in these conditions is the result of increased resorption of bone tissue, as confirmed by the findings from histologic and morphometric studies of the median section of the diaphysis of the femur in rats. A picture of marked osteoporosis was found in the proximal metaphysis of the tibia. The changes observed in different bones are similar, but in the spongy substance they are seen to a greater degree than in compact bone. These differences probably result from the more intensive metabolic processes in the spongy bone; and moreover, a 29-day period of terrestrial rehabilitation was insufficient for complete resolution in the bone tissue and recovery of the level in control animals. It is possible that the formation in the bone tissue of readily soluble, low-substituted calcium nitrate salts entering the interstitial fluid and blood play a role in the mechanism involved in the alteration of mineral metabolism in weightlessness [21].

We have also studied the trends in and degree of bone changes in tortoises undergoing spaceflights lasting from 19 to 90 days [22]. It has been established that under the influence of spaceflight factors lasting 60-90 days in tortoises moderate osteoporosis develops in the epiphyses and metaphyses of the long bones, without change in the microstructures retained. The differences from rats lie in the rate at which the dystrophic processes develop. Whereas in rats loss of the bone mass in the spongy structures may reach 20% in 19 days, in tortoises it does not exceed 4-8% after 60-90 days. This may be the result of the lower intensity of metabolic processes in the tortoises.

Analysis of our own and other published data on the degree of changes in the skeleton in man and animals has shown that the level of calcium loss in man during spaceflight is close to that observed under bed-rest conditions, and this model therefore can be considered adequate for weightless conditions as applied to the skeletal system. Patterns in the development of osteoporosis when the extremities are nonsupportive correspond to these patterns in individuals in hypodynamia. Quantitative indexes for loss of bone tissue, that is, the measure of osteodystrophy, in dogs in the spongy tissue of the distal epimetaphyseal field of the femur, average 35% with individual variations from 24% to 46%, while in rats in an analogous model, loss of mass in the spongy substance has amounted to 34%, and in man, 35% [28].

The 35% maximum loss of spongy substance occurring when the weight load is removed is evidently a universal value, while retention of the remaining bone mass regardless of the functional status of the extremities is established by genetically determined mechanisms. It has been shown that the rate at which these values are reached depends on many factors, among which the initial density of the bone tissue must be mentioned; in the vertebrae of healthy individuals, for example, it varies between broad limits [26]. Resistance to the onset of osteoporosis is higher in bones with a denser compacting of tissue, and X-ray diagnosis of osteoporosis is made in them later than in bones with a low density. Attention should also be drawn to the fact that osteoporosis in hypodynamia, including in weightless conditions in man, develops first in the spongy substance of the axial skeleton, whose main mass is concentrated in the vertebral column. After achieving maximum rarefaction for a "load-free" vertebral column, further atrophy of the bone tissue ceases; this occurs within periods up to 1 year; while a negative calcium balance continuing beyond such periods is probably the result of resorption of compact bone [28].

Thus, at present the patterns of osteodystrophy in the weight-free skeleton have been established in the main, and studies have been made at an up-to-date methodological level of the changes in the mechanical properties of bone, essential for predicting traumatism of the skeleton, primarily the vertebral column, following hypodynamia and weightlessness.

Changes in the skeleton occurring in weightlessness and models of weightlessness should be regarded as adaptation to the conditions of absence of weight load on the locomotor apparatus. The "skeleton of weightlessness" or "skeleton of hypodynamia" formed as the result of adaptation possesses new properties, the chief of which is decreased mass and lower mechanical properties as the

result of changes in the processes of the restructuring of bone tissue stemming from the removal of load from the supportive skeleton and general neurohumoral shifts in the body. Adaptation to the conditions of weightlessness or bed rest, expressed in atrophy not only of the skeletal but also the muscular system, raises a whole range of problems.

First, the return of an organism from conditions of hypodynamia to the previous force load requires a new adaptation that may continue for a prolonged period. It is probable that in order to facilitate readaptation, adaptation should be "slowed down" or at least not permitted to reach its completion in weightlessness (or models of weightlessness) by means of physical exercises and the use of pharmacological agents. Second, establishing a new level of neurohumoral regulation of mineral metabolism in hypodynamia may lower the resistance of the skeletal system to various pathogenetic factors, that is, functional changes may become pathological, causing the development of progressive osteoporosis and increasing the risk of fractures, the desposition of mineral salts outside the skeleton and so forth. Third, systemic and prolonged impairment of phosphorus-calcium metabolism results in changes in neuromuscular excitability, contractility, membrane permeability and other processes depending on it.

The questions discussed here are of great importance not only for the pathophysiology of extremal conditions but also for various fields in medicine where studies are being conducted on the etiology and pathogenesis of diseases of the locomotor apparatus and impairment of mineral metabolism and on developing ways of preventing and treating them.

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LIQUID ELECTROPHORESIS, ISOELECTRIC FOCUSING AND ISOTACHOPHORESIS UNDER MICROGRAVITATION CONDITIONS

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA B: GEOLOGICHESKIYE, KHMICHESKIYE I BIOLOGICHESKIYE NAUKI in Russian No 4, Apr 84  
(manuscript received 24 May 83) pp 56-60

AZHITSKIY, G. Yu., TROIJSKIY, G. V., corresponding member of Ukrainian Academy of Sciences, MITICHKIN, O. V., SHARAYEVA, T. K., VAVIROVSKIY, L. A. and LEPSKIY, A. A., Crimean Medical Institute, Simferopol'

[Abstract] A study was made of the resolutions achieved by electrophoretic methods: electrophoresis, isoelectric focusing and borate-polyol artificial pH gradients and isotachophoresis under weightless conditions. Electrophoretic experiments were performed on a universal installation consisting of interchangeable, universal and sealed electrophoretic columns, a supporting bar, power supply, gradient mixer, pumps for buffer solution and biologic preparation input. Electrophoresis of cells was performed with tris-glycine buffer solution containing EDTA as an antiaggregating additive add 6% saccharose to create isoosmotic conditions. The resolution of the method was increased by a factor of 10 to 15 for isoelectric focusing, 4 to 5 for isotachophoresis and electrophoresis by weightlessness. The apparatus used operated reliably for up to 48 hours.

[161-6508]

HEMATOENCEPHALIC BARRIER UPON EXPOSURE TO IONIZING RADIATION WITH NORMAL AND ALTERED GAS MEDIA

Moscow KOSMICHESKIYE ISSLEDUVANIYA in Russian Vol 22, No 2, Mar-Apr 84  
(manuscript received 17 Jan 83) pp 297-305

ANTIPOV, V. V., DAVYDOV, B. I. and USHAKOV, I. B.

[Abstract] Many factors have been studied in terms of their influence on the blood-brain barrier, but information on factors influencing the barrier in flight is still insufficient. The most significant changes should be

expected upon exposure to ionizing radiation while breathing an altered gas mixture. Studies were performed on 200 female mice exposed to unilateral irradiation by  $^{60}\text{Co}$  gamma quanta at 1.311 mA/kg while breathing ordinary air, 8% hypoxic mixture of 100% oxygen. Blood-brain barrier permeability was measured by intraperitoneal administration of a label consisting of 0.8 ml of a 10% acid fuchsin solution, which normally penetrates the blood-brain barrier poorly. It was found that permeability of the barrier increased with nonuniform irradiation of the head or trunk, though this effect did not occur with combined gamma irradiation and hypoxic hypoxia. Hypoxic hypoxia and hyperoxia reduced blood-brain barrier permeability in irradiated animals. Greatest influence on permeability was that of 1.29-2.58 Ci/kg gamma irradiation of the trunk. Blood-brain barrier permeability depended on the relationship of doses received by the body and head, i.e., nonuniformity of irradiation. Figures 3; references 39: 24 Russian, 15 Western.  
[130-6508]

UDC: 575.224.232:595.773.4

FREQUENCY OF RECOMBINATIONS, NONDISJUNCTION AND RUPTURE OF CHROMOSOMES IN MALE DROSOPHILA MELANOGASTER EXPOSED TO ORBITAL FLIGHT

Moscow GENETIKA in Russian Vol 19, No 12, Dec 83  
(manuscript received 11 Aug 81; final version received 25 Feb 83)  
pp 2008-2013

FILATOVA, L. P., VAULINA, E. N. and GROZDOVA, T. Ya., Institute of General Genetics, USSR Academy of Sciences, Moscow

[Abstract] The purpose of this experiment was to study both the frequency of mitotic recombination and the frequency of nondisjunction of the chromosomes in meiosis in male Drosophila exposed to space flight factors in the Salyut-6 spacecraft. Individual cultures were maintained from each male for 18 days after the flight, each male crossed with 3 to 5 females. Vibration and acceleration factors were also modeled on a centrifuge. Space flight factors increased the frequency of nondisjunction, chromosome ruptures and mitotic combinations. Vibration and acceleration alone did not produce the same spectrum of changes observed in space flight. Cosmic radiation and weightlessness appear to be the major causes of the changes observed.

References 18: 9 Russian, 9 Western.

[131-6508]

EMOTIONAL STRESS AND CIRCULATION

Moscow VESTNIK AKADEMII MEDITSINSKIKH NAUK SSSR in Russian No 4, Apr 84  
(manuscript received 29 Jul 83) pp 38-45

PEDOROV, B. M., PONOMAREV, Yu. T., STREL'TSOVA, Ye. N., SINITSYNA, T. M.,  
SEBEKINA, T. V., PODREZOVA, N. A., TKACHEV, V. V., DOMRACHEVA, M. V.,  
and BOBKOVА, A. S., Moscow

[Abstract] Stress reactions and their influence on circulation were studied in various situations, including normal motor activity and various durations of long-term hypokinesia, under which the persons studied were maintained in strict bed rest for several weeks or months. Hypokinesia was found greatly to increase the circulatory reaction to moderate alarm such as that experienced during dental procedure. Hypokinesia causes asthenization of the nervous system, functional state imbalance on the higher autonomic centers of the brain and deviations in hemodynamics, decreasing adaptation capabilities of the organism so that functional loads previously well tolerated begin to cause reactions extending beyond the physiological norm. The influence of 182-day hypokinesia on changes in circulation upon stress caused by mental work were studied. Exercises performed with a bicycle odometer and spring loaded hand operated expanders during bed rest greatly reduced the abnormal reactions observed. References 33: 32 Russian, 1 Western.

[160-6508]

## SPACE ENGINEERING

### EFFECTS OF ENVIRONMENT ON SPACECRAFT MATERIALS

Moscow VOZDEYSTVIYE OKRUZHAYUSHCHEY SREDY NA MATERIALY KOSMICHESKIKH APPARATOV (NOVOYE V ZHIZNI, NAUKE, TEKHNIKE: SERIYA "KOSMONAVTIKA, ASTRONOMIYA") in Russian No 4, Apr 83 pp 2-6

[Annotation and introduction from book "Effects of Environment on Spacecraft Materials (News in Life, Science and Technology: 'Cosmonautics and Astronomy Series')", Izdatel'stvo "Znaniye", 64 pages, illustrated]

[Text] The processes of space environment effects on the [structural] materials of satellites, orbital and interplanetary stations determine characteristics such as operating time, reliability, work and defense functions during manned flights. This pamphlet describes current conceptions of these processes, the study of which will determine further progress of space exploration. It is intended for all those concerned with current problems of cosmonautics.

#### Introduction

Since the early 1970's, development of cosmonautics has been characterized by its ever increasing penetration into different areas of practical endeavor of mankind and use of space technology to solve the most diverse applied problems. Studies of natural resources and meteorology, navigation and geodesics, communication systems and technology--such as a far from complete list of areas, in which the latest achievements of space-rocket technology and space instrument building are used.

In our country, enormous attention had always been devoted to development of space systems for purposes of the national economy. In July 1975, an editorial in the newspaper, PRAVDA, stated: "... Cosmonautics is consistently increasing its contribution to solving problems of the national economy. The demands for its 'services' are also growing consistently as more and more scientific institutions, enterprises, organizations and agencies are submitting applications for conducting research of interest to them in space. With each new mission, there is increase in the return from research conducted in near-earth orbits...."

Different types of space vehicles (SV) are used to fulfill national economy programs in our country: permanent manned orbital space stations (OSS) of the Salyut series, artificial earth satellites (AES) of the Meteor series that

are intended for meteorological observations and investigation of natural resources, Molniya [Lightning], Ekran [Shield], Raduga [Rainbow], Gorizont [Horizon] and other series of AES.

In the future, there will be new far-reaching plans on the agenda of cosmonautics, such as development of solar space electric power plants with 5-10 GW power, the solar batteries of which will have an area of tens of square kilometers and weight of tens of tons, assembly of technological-production complexes and radioastronomical observatories with unique capabilities in near-earth orbits.

At a time when cosmonautics is becoming an important element of the management system, questions of profitability and economic effectiveness of using space technology acquire special significance. Considering the fact that the cost of operating an SV is many times lower than the cost of developing it and inserting it in orbit, it is necessary to make every effort to extend the service life of SV's. At the present time, the requirement is being advanced more and more often that space vehicles must function reliably in orbit for 10 or more years, whereas for the planned solar electric power stations the service life should be 20-30 years, considering the enormous expenses of developing them (15-40 billion dollars, according to estimates of foreign specialists).

Resistance of construction materials and elements of SV equipment to exogenous factors plays a most important part in assuring long-term and uninterrupted operation of space vehicles. An SV is exposed to a set of space environment factors: profound vacuum, corpuscular and electromagnetic radiations of different types, meteoroids, weightlessness, etc. SV's used to explore planets could be exposed to rather specific conditions. For example, on the surface of Venus the temperature reaches 500°C and pressure of about 90 atm; on the surface of Mars, an SV could be exposed to dust storms, i.e., flow of soil particles moving at the rate of 30-100 m/s. When flying to the outer planets of the solar system (Jupiter, Saturn), SV's traverse the asteroid belt that is situated between the orbits of Mars and Jupiter. Jupiter's powerful radiation belt presents a serious danger to SV equipment as it flies near this planet.

The diversity of space factors affecting an SV, the complex energy spectra of corpuscular and electromagnetic radiations, the possibility of exposure to space factors in different combinations and in different order--all this makes it considerably more difficult to study and predict the behavior of SV materials in the space environment. Intensive studies in this field, which were prompted by the demands of intensively developing space technology, resulted in development of an actually new scientific direction, space materials technology, the tasks of which include experimental and theoretical investigation of changes in physical properties and operating characteristics of construction materials under the influence of space factors, development of new materials,<sup>1</sup> development of means of protecting materials and elements of equipment against space factor effects.

In the years of its development, space materials technology has made considerable strides, primarily in assuring resistance of materials to superhigh vacuum and ionizing radiation. Thanks to the research, radioresistance of elements

of solar batteries, optical systems, electronic equipment, systems of SV heat regulation, etc., has been improved. Specific steps have been proposed for protection of the most vulnerable elements of onboard equipment. The long-term uninterrupted operation of the Soviet lunar modules, Lunokhod-1 and Lunokhod 2, effective function of Salyut-6 OSS for almost 5 years, the successful studies of the atmospheres and surface of Venus and Mars by descent vehicles of Soviet unmanned interplanetary stations are impressive evidence of the achievements in assuring viability of SV's.

With the development in our country of Salyut-type OSS, there was intensive development of experiments in the field of space technology. Many such experiments, including some following international programs, were performed aboard Salyut-6 OSS. Work in this direction is continuing aboard Salyut-7.

Expansion of the areas of practical application of space technology inevitably increases the requirements as to quality of construction materials and poses new, sometimes unexpected problems in the area of space materials technology. As an example, we can mention the problem of accumulation of considerable electrostatic charges aboard SV's, which we encountered only in the early 1970's, when we launched the first geostationary AES's (altitude of orbit 36,000 km).

Thus, space materials technology, the history of which goes back only slightly more than 20 years, continues to develop intensively, on the basis of the latest achievements in allied branches of science and engineering and, in turn, making its contribution to development of allied branches--vacuum and radiation engineering, technology of semiconductor instrument building and technology of production of extra-pure materials.

This brochure sheds light on the most pressing problems of space materials technology; it discusses the physical and applied aspects of various phenomena that occur under the effect of space factors on materials and elements of SV; it describes the principles and some methods of simulating the effects of space factors and demonstrates the prospects of development of space materials technology.

#### FOOTNOTE

1. The latter is often referred to so-called space technology. However, the opinion is becoming increasingly popular that "such scientific directions as 'space materials technology' and 'space technology' are essentially the same science dealing with the behavior of materials, methods of obtaining and joining them in space" ("Kosmicheskoye materialovedeniye i tekhnologiya" [Space Materials Technology and Engineering], A. S. M. Okhotin editor-in-chief, Moscow, Nauka, 1977). Since we adhere to this view, we shall unite hereafter both disciplines under the same name, space materials technology.

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10,656  
CSO: 1866/97

## PROSPECTIVE USES FOR DIFFUSION WELDING IN VACUUM

Moscow KRSNAYA ZVEZDA in Russian 4 Aug 84 p 3

[Article by Nikolay Fedotovich Kazakov, Doctor of Technical Sciences, Professor of the Moscow Aviation Technology Institute imeni Tsioikovskiy, meritorious scientist and engineer of the RSFSR, Lenin Prize laureate]

[Abstract] The author discusses the principles and features of diffusion welding in a vacuum, and he mentions some of the types of materials that can be welded most successfully by this method. For example, it is said to possess a number of potential advantages for space welding operations which are envisaged in the future, particularly the welding of metal structurals. The high vacuum of outer space and the use of the simplest devices to transmit compression pressure ensure reliable joining of various combinations of materials, the author explains. He also claims that the use of the diffusion method can shorten time for the repairing of space technology.

Nuclear power engineering, high-energy and high-temperature physics, polymer chemistry, radio electronics, superhigh-pressure physics, computer technology and rocket building are mentioned as other fields in which diffusion welding holds unusual promise. Diffusion technology is said to be of particular interest in connection with work on the intensification of welding through the action of powerful electric and magnetic fields; welding superconductive materials while preserving their properties in zones of joints; processes for welding ionic, laser and piezoelectric crystals; new types of heating for specimens that are to be joined, including laser heating in a glow discharge; and the welding of reactive (fuel and radioactive) materials for the purpose of obtaining new high-performance fuel elements. Diffusion welding is expected to be an indispensable part of processes for the production of ceramic engines which have been proposed.

FTD/SNAP  
CSO: 1866/25

UDC: 536.24.01

ONE METHOD OF SOLVING THE PROBLEM OF UNSTEADY HEAT EXCHANGE OF A BODY AND ITS ABLATION

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA,  
ASTRONOMIYA in Russian No 2, Apr 84 (manuscript received 24 Jun 82) pp 62-66

POLYANSKIY, A. F. and SKURIN, L. I.

[Abstract] A relatively simple method is suggested for solution of the unsteady heat exchange and ablation problem. The authors propose a modification of the method of straight lines with approximation of the temperature field of a body in the direction of its major motion by a cubic spline. The method is tested in a one-dimensional model by comparing it with a known precise solution for the problem of heating and ablation. In contrast to the method of grids at each calculation moment in time the profile of temperature in the body is described by a function which is continuous together with its first and second three-dimensional derivatives. For heat exchange problems characteristic for hypersonic flow, only a few bands need be introduced in the direction of the major change in temperature. A significant savings in machine time is achieved since the problem can be solved by a limited number of differential equations for  $\eta_1(t)$ .

Figures 2; references: 4 Russian.

[156-6508]

## SPACE APPLICATIONS

### SPACECRAFT-AIDED RESEARCH DISCUSSED AT GEOLOGY CONGRESS

Ashkhabad TURKMENSKAYA ISKRA in Russian 10 Aug 84 p 3

[Article by N. Konstantinov and Yu. Shchavyakov, correspondents]

[Excerpt] A "Space Geological Map of the USSR" turned out to be one of the highlights of the 27th International Geological Congress. No other country in the world has such a map at present.

A discussion of problems of satellite-aided geology and comparative planetology which was included in the program of the congress in Moscow attracted the attention of the more than 200 delegates and guests. At the request of TASS correspondents, R. N. Mozhayev, general director of the "Aerogeologiya" association, told about achievements of our scientists in this field.

"Structures whose existence could only be suspected by geologists in the past become visible on the Earth's surface from the altitude of an orbital flight. This pertains primarily to ring-shaped structures hundreds of kilometers in diameter, and to linear transcontinental faults of the Earth's crust which are thousands of kilometers longs.

"More than 4,000 structures have been detected from space on the territory of the USSR and entered on maps.

"Soviet orbiting stations, 'Soyuz' spaceships and satellites of the 'Meteor' and 'Fosmos' series are equipped with photographic and scanning instruments. MKF-6 cameras, for example, are capable not only of distinguishing details only 15 kilometers in size in a locality; they also can determine the chemical composition of rocks on the basis of remote spectrograms."

FTD/SNAP  
CSO: 1866/25

UDC 551.521.3:551.507.362

ENHANCING PRECISION OF REMOTE TEMPERATURE SENSING DATA FROM SATELLITES UNDER CLOUDY ATMOSPHERIC CONDITIONS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 30 May 83) pp 15-22

PLOKHIENKO, Yu. V. and USPENSKIY, A. B., State Scientific Research Center for the Study of Natural Resources, Moscow

[Abstract] Cloud cover is the major impediment to radiometric IR band measurements of thermal radiation from the earth-atmosphere system. Present algorithms for the remote determination of temperature with partial cloud cover which have been proposed in the literature are difficult to compare with each other since no analysis has been made of their accuracy and the few attempts at estimating the information content and optimizing the composition of such measurements are based on considerations of a physical nature or are tied to a specific algorithm. This paper partially fills in these blanks by proposing a physical statistical model for IR measurements made in the presence of multilayer, partial cloud cover. The model is used to derive optimal estimates of the temperature distribution and the effective cloud cover density. It is assumed that the clouds can be represented by a thin absorbing layer (shield) at a specific temperature and altitude, and that the cloud layers have reflectivities close to zero. The clouds are assumed not to overlap. Cloudiness produces a sharp drop in the precision of any estimate for the atmospheric layer under the cloud cover. The information content indicator falls off as the cloud cover altitude increases. The calculations demonstrate that the accuracy of estimates of the effective cloud cover for two adjacent layers is poor, i.e. adjacent or close layers are poorly distinguishable. The precision of estimates of the effective cloud cover improves as the spacing between the levels increases and the altitude of the top layer rises. The analytical expressions derived here are not illustrated with any sample calculations or hardware applications. Tables 1; references 9: 6 Russian, 3 Western.

[126-8225]

UDC 528.72(202):535.36

IMPACT OF FLUCTUATIONS IN OPTICAL PROPERTIES OF ATMOSPHERE ON THE RATIO OF SPECTRAL BRIGHTNESSES FROM REMOTE SENSING OF AGRICULTURAL LAND

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 6 Jul 83) pp 23-24

AKHMEDOV, Sh. A. and USIKOV, D. A., Scientific Production Association for Space Research of the AzSSR Academy of Sciences, Baku and the USSR Academy of Sciences Institute of Space Research, Moscow

[Abstract] The interpreted data from multiband video images made from space is distorted by the atmosphere, the optical parameters of which fluctuate around average values and are generally unknown. The mean statistical error in determining the brightness ratio of a target object at two different wavelengths is determined from measurements at 0.63 and 0.57 micrometers for the cities Krasnoyarsk, Markovo, Riga, Omsk, Pechora and Gur'yev, with the average values of the optical thickness at these wavelengths and their dispersions being taken from actinometric station data. An analytical expression is derived for calculating the dispersion of this ratio. The maximum relative error reaches 10%, an amount which can be significant in research and practical applications. Tables 1; references: 2 Russian.  
[126-8225]

UDC 551.501.776:629.78

DETERMINATION OF ALTITUDE OF CLOUD COVER TOP FROM 'METEOR' SATELLITE DATA

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 9 Sep 83) pp 25-34

KOPROVA, L. I. and BAKHAMATOV, A. Ye., Institute of Oceanology imeni P imeni P. P. Shirshov, USSR Academy of Sciences, Moscow and State Scientific Research Center for the Study of Natural Resources, Moscow

[Abstract] The second generation "Meteor" satellites, which have an IR radiometer with better resolution than those in their first generation counterparts, enable greater precision in the measurement of the altitude H of the upper cloud cover boundary. The value of H is determined from satellite measurements of the radiation exiting the earth-atmosphere system in the 8 - 12 micrometer transmittance window, supplemented with apriori data on the stratification of the atmosphere. Since the IR measurements are made at only one wavelength, a fundamental difficulty is the lack of apriori data on the atmospheric structure at the time of the measurements. A timely determination of H requires the use of global climatic data on the meteorological parameters of the atmosphere as the apriori information. This paper is a detailed analysis of an improved satellite measurement technique for H which resolves the following problems: 1) The determination

of the scope and complement of the apriori global information; 2) The generation of the requisite catalog and procedure for its timely use; 3) The automation of the identification of IR data on cloud conditions; 4) The procedure for the use of IR measurements in mapping the cloud top altitude and taking into account the effect of the atmospheric layer over the clouds on the IR measurements. The altitude determination procedure was checked by comparing synchronous radio sensing and satellite data for two regions where cloud shape and altitude differ substantially: the White Sea (1978) and the tropical latitudes of the Indian Ocean (1977). The following are summarized in extensive tables: the satellite and radio sensing data on H; the transmittance function of the atmospheric layer over the clouds as a function of latitude in both the northern and southern hemispheres in July and January; the value of H based on radio sounding data and calculated from the measured radiation temperature and climatic data as well as estimates of the impact of the atmospheric layer above the clouds on the determination of H. Maps of H produced during the "POLEX-83" period intended for the study of circumpolar currents demonstrated that this technique more completely takes into account the effect of cloud cover on atmospheric and oceanological processes. Data on H can also be used for weather forecasting in regions poorly covered by meteorological observations. Figures 4; tables 5; references 14: 10 Russian, 4 Western.

[126-8225]

UDC 528.77:550.814+629.78(470.4+574.1)

#### LANDSCAPE INTERPRETATION CAPABILITIES USING SPACE PHOTOGRAPHS OF REGIONS OF A MULTISTAGE PLATFORM MANTLE STRUCTURE

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 8 Jun 83) pp 35-43

OBRYADCHIKOV, O. S. and PETROV, S. Ye. (deceased), All-Union Scientific Research Petroleum Geological Prospecting Institute, Moscow

[Abstract] Space photographs of such regions as the sub-Urals plateau (a semi-arid plain practically devoid of vegetation) exhibit a uniform, washed-out shading with little contrast. This paper analyses the information content of such local regional space photos for the eastern part of the Caspian basin, an area with a complex structure of the lower strata of the platform mantle (down to the lower Permian inclusively) and extensively developed salt dome tectonic systems. It is shown that using the deviation of the plan view position of the lineaments from the projection onto the ground surface of the fracture faults corresponding to the lineaments revealed by deep seismic prospecting one can determine the inclination angles of the planes of their displacements. For the Emba and Temir river faults, these angles average 45° and 55° respectively. While local space photos can be of practical importance in terrain interpretation when studying the deep structure and developmental history of the most complexly structured ancient platforms with a multistage mantle, careful combined analysis of space and

geophysical data is still required. When geophysical data are inadequate, unambiguous interpretation of space photographs is impossible, but they will be of definite value in assisting with the planning of further ground studies. Figures 3; references: 25 Russian.

[126-8225]

UDC 535.343+535.274.4

INTERPRETATION OF MULTIBAND PHOTOGRAPHS MADE DURING 'TELEFOTO-80' EXPERIMENT FOR THE PURPOSE OF DISCRIMINATING AGRICULTURAL CROPS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 8 Jun 83) pp 44-47

KACHIN'SKI, R., Institute of Geodesy and Cartography of the Polish Academy of Sciences, Warsaw

[Abstract] Aerial photographs were taken from an AN-30 laboratory aircraft on July 27th, 1980 from about 2,500 m (scale of 1:20,000) with an MKF-6M during the "Telefoto-80" experiment conducted within the framework of the "Intercosmos" program. The photos were interpreted to ascertain the following crops: corn, potatoes, beets, wheat, flax, meadow and pasture land, barley, oats, and rye and rape in the area around the Polish villages of Kulin and Tsesazhovitse. The results of interpreting color photos of 119 fields near the former and 132 fields near the latter locations show: 1) The natural colors of crops determined visually yield the same results for rye and wheat, corn and potatoes as well as meadow and pasture lands. The incorporation of an infrared analysis channel makes it possible to discriminate between corn and potatoes, and between rye and wheat. The average identification accuracy for individual agricultural crops ranged from 86 to 100% (with the exception of oats, which was only correctly identified 35% of the time, since it was incorrectly identified as flax because of the small number of fields). Tables 5; figures 1; references: 2 Russian.

[126-8225]

UDC 551.24+553.042:528.77+629.78

USE OF SPACE PHOTOGRAPHS FOR ANALYSIS OF STRUCTURAL AND DYNAMIC CONDITIONS  
OF FORMATION OF ANCIENT PHLOGOPITE AND APATITE DEPOSITS

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 7 Jul 83) pp 48-54

ZINATOV, Kh. G. and VAFIN, R. F., All-Union Scientific Research Institute  
for the Geology of Nonmetallic Minerals, Kazan

[Abstract] Despite the fact that the Central Aldan shield has experienced several stages of tectonic and magmatic activity over the last 1.5 to 2 billion years, which apparently destroyed some of the pre-Cambrian deposits of phlogopite and apatite, such deposits have been dispersed, but nonetheless preserved. This paper analyzes possible factors responsible for the differences in the structural development and preservation of commercial accumulations of phlogopite and apatite. Space photographs taken from the 25th "Meteor" satellite show a pattern of diagonal fault lines forming a distorted rhombic grid which reveals the regularity of phlogopite and apatite deposits. Stress fields are found to be responsible for the creation of structures in pre-Cambrian times capable of concentrating phlogopite and apatite and preserving these deposits in Phanerozoic times. The application of the tectonic analysis proposed here to problems of geological interpretation of space photographic data resolves difficulties related to the systematic analysis of the dynamic relationship between deposits of useful minerals and tectonic structures and is thus applicable to the regional analysis of ore centers of other minerals. Figures 3; references: 14 Russian.

[126-8225]

UDC 551.244:528.77+629.78(477.9)

USING REMOTE PHOTOGRAPHS IN PROSPECTING FOR HYDROCARBONS ON THE KERCH  
PENINSULA

Moscow ISSLEDUVANIYA ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 5 Apr 83) pp 55-59

KHNYKIN, V. I. and KOLODIY, N. V., Ukrainian Geological Prospecting  
Scientific Research Institute, L'vov

[Abstract] Satellite TV images, photographs from manned spacecraft and aerial photographs were interpreted to ascertain the configuration of lineaments in the Indolo-Kuban trough on the Kerch Peninsula. The lineaments are grouped into two systems: The first, which is the most extensive and pronounced in photographs with the greatest generalization, contains lineaments running parallel to the large tectonic structures and emphasizes individual structural elements in some cases; the second group is a system of lineaments running primarily transverse to the strike of the local folds,

and can usually be traced intermittently over long distances. The latter can serve as tectonic shields for pools of hydrocarbons. Prospecting for such pools in the Nizhnemaykopskiy deposits is underway on the Kerch Peninsula at the present time. It has been shown that there are no reservoirs in the crests of the structures in the southwest plain. Considering the presence of transverse fractures here, local folds in this area can be treated as consisting of individual blocks of pools. The prospecting is to be started in these blocks from the periclinal portions of the folds, considering them to be independent prospecting targets from the central portions of the structures, even in those cases when seismic surveys do not indicate transverse fracturing. It is appropriate during seismic studies when preparing structures for drilling to devote special attention to sections of intersections of seismic profiles and lineaments for searches for poorly pronounced faults. A detailed map of lineaments on the Kerch Peninsula and such features as mud volcanoes and gas condensate pools is provided. Figures 2; references: 2 Russian.

[126-8225]

UDC 631/635:629.78

CATALOGING THE SPECTRAL BRIGHTNESS COEFFICIENTS OF THE FORESTED REGION OF THE EUROPEAN TERRITORY OF THE USSR

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 14 Jun 83) pp 60-66

ROSS, Yu. K. and PETERSON, U. K., Institute of Astrophysics and Atmospheric Physics of the Estonian SSR Academy of Sciences, Tartu and Tartu State University

[Abstract] Data from ground, aircraft and helicopter measurements of the spectral brightness coefficients of the earth's surface which were obtained during 1976-1982 by the Institute of Astrophysics and Atmospheric Physics of the Estonian SSR Academy of Sciences, are used to compile a catalog of these brightness factors for the northwest portion of the European area of the USSR for all seasons of the year. Three wavelengths were used: 0.550, 0.675 and 0.795 micrometers. A classification system is developed for the mapping of the surface which is comparable to the land use and land cover scheme of Anderson, et al., and corresponds to the second level of this classification in terms of the degree of detail. Some 32 different classification categories were selected. The average values of the spectral brightness are summarized for these categories in tabular form for five periods of the year: winter, spring, summer, late summer and fall. The reliability of the catalog requires that the spectral brightness coefficients be supplemented with variation coefficients, however, there is still not sufficiently reliable data for this. The defining criteria for the five seasons used here are discussed. The catalog has practical applications, in particular, the compilation of spectral brightness maps of the earth's surface. Tables 1; references 32: 22 Russian, 10 Western.

[126-8225]

REGRESSION ANALYSIS OF AIRCRAFT AND GROUND MEASUREMENT DATA ON VEGETATION COVER

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 19 Jul 83) pp 67-75

KLIMENKO, O. Ya. and KOZODEROV, V. V., Department of Computational Mathematics of USSR Academy of Sciences, Moscow

[Abstract] Data from aircraft measurements using the MKF-6 multiband camera and ground measurements of the phytometric parameters of winter wheat, e.g. the height, thickness, leaf surface area, phytomass dry and moist weight by volume, vegetative soil shading and other parameters for wheat in the Kherson test area in 1981, were subjected to regression analysis in order to determine the relationship between the remote measurements and ground measurements for the vegetation-soil system. The regression analysis consisted in calculating the coefficients of the linear step-by-step regression, the correlation matrices and residual dispersion of the significant parameters. The findings are: 1) The inadequate precision in relating the aircraft and ground measurements to each other for the April phenophase resulted in considerable errors in the predictive model; 2) Results were much better for the June phenophase when the ground data were better tied to the aircraft measurements; 3) Very low correlation coefficients are noted between the denseness and the other parameters, and the multiband brightnesses. The lack of sufficient statistical data does not now allow for an explanation; 4) A comparison of calculations based on single factor models, when the vegetation index and straight-line distance was taken as the factor, showed that the results obtained for the straight-line distance are substantially better. The need for an experimental check of these regression data by means of independent materials is noted. Tables 2; figures 3; references 20: 8 Russian, 12 Western.

[126-8225]

DIRECT REGRESSION ANALYSIS OF REMOTE SENSING DATA (USING EXAMPLE OF GRASS COVER)

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 8 Aug 83) pp 76-86

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[Abstract] The spectral brightness coefficients of areas of Baykal feather grass (*Stipa*) were measured in the Mongolian Peoples' Republic during June and July of 1982 in 20 spectral bands from 0.4 to 0.8 micrometers with a

terrain resolution of about  $0.1 \text{ m}^2$ . Some 10 characteristics of the grass state were defined for each test area; about 200 points were measured for four areas with easily distinguishable types of grass. The portable ISOKh-020 spectrometer had a field of view of  $13^\circ$  and the measurements were made in clear weather at wind speeds of less than  $2 \text{ m/s}$ . A detailed regression analysis is made of the following data: 1) Maximum leaf height in a given test point; 2) Heights of the 5th and 10th leaves of the grass, measured from ground level; 3) Damp biomass per  $\text{m}^2$ ; 4) Damp biomass per  $\text{m}^2$  with respect to the four major groups of species; 5) Moisture content in the different species of vegetation; 6) Overall moisture content in vegetation; 7) Soil moisture content; 8) The first four semi-invariant probability distributions of the total projective soil cover at a test point; 9) The same, for the projective cover of just the green vegetation; 10) The same, for the projective soil shading by the leaves; 11) The same for the distribution of the leaf inclination angles; 12) The same, for the leaf azimuth distribution. It was found that the measurement data (i.e., the vegetation phase) had the greatest impact on the spectral brightness of all of the variables studied. The stability of the spectral course of the regression quality indicators with a change in the input data is good. When the number of variables describing the vegetation state increased from 1 to 3, the regression quality improved slightly. There are some variables which are obviously better than others, and in this case these were the total biomass, projective coverage, moisture content and average leaf inclination angle. For the majority of variables, the optimal spectral ranges in terms of quality are close to 0.43, 0.65 and 0.75 micrometers. Experiments of this type can provide reliable data on the function relating vegetation states to spectral brightness and thus on optimal spectral channels, assuming careful checking of systematic errors, especially those correlated with the measured variables. Tables 1; figures 8; references 4: 2 Russian, 1 Western, 1 Western in Russian translation.

[126-8225]

UDC 528.7:681.3

#### INTERACTIVE PROCEDURES FOR DISCRIMINATING AND RESTORING CONTOUR LINE NETWORKS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 1 Aug 83) pp 87-97

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[Abstract] In computer-aided topical mapping using data derived from aerial and space photographs the contour lines comprising the structural outlines of a map can be fed into the computer in various ways (encoder, TV or optomechanical input unit). This paper is a detailed analysis of a series of interactive procedures which allow an operator controlling a display to discriminate the sketched outline on a photograph and reproduce it on the

screen of the display within the precision allowed by computer digitization errors. It is assumed that the contour outlines are sketched on the photos by the person interpreting them with white gouache paint. The discrimination of the contour lines is accomplished by either an "indistinct" mask or a "logic" mask. Following the discrimination procedures, the contour outlines in the marker display memory are in binary form. The recovery procedures are based on the use of a domain with dimensions of 3x3 store locations. The techniques and decision making rules for the reproduction of the contours are discussed in depth and illustrated with sample maps, showing the intermediate stages. The proposed procedure is used in the "Lesproyekt" All-Union Association and employs the "Perikolor" display system with a KONTURY package of programs intended for the primary processing of contour line data from remote photographs. Tables 1; figures 6; references 4: 2 Russian, 1 Western. 1 Western in Russian translation.  
[126-8225]

UDC 629.19:551

#### TERRAIN ILLUMINATION CONDITIONS WHEN TAKING SCANNING PHOTOGRAPHS FROM SPACE

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 2 Sep 83) pp 98-106

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[Abstract] The primary factors influencing the illumination of the ground in the case of geological and geographic interpretation of scanner photos taken from space under cloudless skies with good atmospheric transparency are the altitude and azimuth of the sun. This paper derives and analyzes expressions for the solar altitude and azimuth for terrain points at the moment they are photographed as a function of the orbital parameters of an earth resources satellite, the photograph dates, the geographic latitude of these points and their distance from the satellite track. It is assumed that the scanner photos are taken from satellites in a circular solar synchronous orbit at an altitude of 600 to 900 km, that the photos are taken during the descending orbital trajectories, i.e. when the satellite is moving southwest in the morning or noontime hours, the earth's surface is represented by a shpere and the orbit is strictly circular and the optical spectrum is used, employing an optical-mechanical scanner with linear horizontal line scanning or using a solid-state MSU-E or the HRV scanner of the SPOT system. All line elements of the photos are assumed to be recorded simultaneously. It is shown that the lighting conditions are practically independent of the satellite altitude and are completely governed by the mean local time of passage of the descending orbit. Quantitative expressions are also found for the change in illumination within any scanning photo and considerations are discussed which allow recommending an optimal value for the local mean time of descending trajectory passage.

Figures 6; references 11: 10 Russian, 1 Western.  
[126-8225]

CALCULATING SOLAR HIGHLIGHT AND SHADELESS AREAS FOR SCANNING PHOTOGRAPHS  
FROM SPACE AND OPTIMIZING LIGHTING CONDITIONS

Moscow ISSLEDOVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 2 Sep 83) pp 107-116

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[Abstract] Light scattering by natural landscape objects exhibits two maxima which fall within the vertical plane having an azimuth coincident with the azimuth of the sun. The first maximum corresponds to the direction of the solar rays (the unshaded region) and the second to the direction of the mirror reflection of these rays from the horizontal plane (the highlighting region). In these two regions, the brightness coefficients of the majority of terrain elements increase sharply and become strongly variable, while the contrasts between different objects as a rule decrease. The spectral contrasts are greatly distorted in the highlight region. Multispectral space scanner photos are thus best made under illumination conditions which minimize the impact of shade-free and highlight regions. On the other hand, the images of terrain objects in these regions yield the maximum information on the scattering indices of the objects. This paper quantitatively describes these two regions as applied to the case of multispectrum space scanner photography from earth resources satellites and the optimization of the ground illumination conditions. The analysis is based on the geometry of the sun-satellite-earth surface system and also treats the question of the duration of the space photography season and its dependence on lighting conditions. Equations are solved for the isolines and centers of the shadeless and highlight regions. The proposed procedures are sufficient for the selection of narrow beam sensors and local mean times for the descending orbit passage for which these regions do not fall in the photos. The influence of background illumination of regions in the northern hemisphere can be substantially reduced by changing over to photography during the ascending orbit trajectories, however, this curtails the available season. Tables 1; figures 6; references: 2 Russian.  
[126-8225]

DISCRIMINATION OF LINEAR CONTOUR ELEMENTS OF SPACE PHOTOGRAPHS BASED ON VISUAL PERCEPTION MODEL

Moscow ISSLEDUVANIYE ZEMLI IZ KOSMOSA in Russian No 2, Mar-Apr 84  
(manuscript received 1 Oct 82) pp 117-124

SMIRNOV, M. V. and ROZANOV, L. N.

[Abstract] Formalization of the description of such objects as lineaments on space photographs in the case of visual interpretation must be based on some model of visual perception. An algorithm constructed from such a model will be heuristic. It is argued that the optimization of the heuristic algorithm is possible using the statistical properties of the images. A model using the following sequence of operations is proposed: in each iteration, the dynamic range of variation in the brightness is subjected to logarithmic transformation; after this, a filter emphasizes all density gradients and simultaneously provides isotropic smoothing; the range of values of the filtered image is then subjected to an exponential transformation. The last operation is a decorrelation, which combines the maximum values of the converted image into lines (ascertaining the skeletal outline). A block diagram of the proposed model, as well as the frequency response of the filters used, are shown. The transition is made from the qualitative model to a statistical one for certain parameters of the heuristically developed algorithm, based on the physical characteristics of the transformed space photographs. The technique is applied to the geological interpretation of tectonic structures of interest in hydrocarbon pool prospecting in the region of the Pechora River mouth. A comparison of visually ascertained and machine interpreted lineaments shows good agreement, while the computer-aided approach notes new elements undetected visually. The computer images also show the shores of water areas, drainage and outlines of large geological structures (which is illustrated with a sketch of the area near the confluence of the Yenisey and Bakhta rivers). These latter features of computer processing must be considered and the discriminated line contour elements therefore do not replace, but rather supplement visually interpreted space photographs, making such interpretation more reliable. The appropriateness of the proposed processing procedure is primarily related to the suppression of the background component. Combined discrimination of the tectonic and background components leads to the appearance of a large number of lines and contours which have no geological confirmation, significantly encumbering the interpretation or rendering it practically impossible. Figures 8; references 19: 18 Russian, 1 Western.  
[126-8225]

UDC 911.62:528.71(-925.22)

PHYSICO-GEOGRAPHICAL REGIONALIZATION OF CASPIAN LOWLAND BASED ON SPACE SURVEY MATERIALS

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA in Russian  
No 1, Jan-Feb 84 (manuscript received 16 May 83) pp 65-70

KOPYL, I. V. and NIKOLAYEV, V. A.

[Abstract] Imagery from Salyut-4 and Meteor and other satellites was used to establish regionalization through analysis of functional internal structures of the natural geosystems consisting of conjunctions of spatial and genetic landscape complexes. Each characteristic physico-geographical area has dominant landscapes shown in the imagery by patterns which can be analyzed according to geometry, optical density, boundaries and other features. The original sea level in the Caspian lowland, has in parts, been affected by exogenous processes such as erosion, eolianism and undermining producing Baer formations and dendritic, striated, spotted, circular-concentric and other identifiable shapes. The regional pattern is built up from textures of landscapes and their morphological subunits. The area breaks down into semi-desert and desert subregions and land use modifications such as agricultural and pasture use are visible. Large-scale morphostructural and zonation lineaments as well as paleogeographical features are often visible. Regionalization is more precise and detailed and shows complex interrelations better than previous versions and can be applied for agricultural, reclamation, conservation and other purposes.

UDC 528.9:551.482.6:528.71

MAPPING OF DYNAMICS OF DELTAS BY SPACE PHOTOGRAPHY

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA in Russian  
No 1, Jan-Feb 84 (manuscript received 7 Feb 83) pp 70-81

YEFREMOVA, O. N. and KRAVTSOVA, V. I.

[Abstract] River delta region dynamics based upon hydromorphological development processes, delta movements seawards and river flow were studied by means of space imagery of the Danube, Amu Darya and Lena deltas from Meteor-Priroda and Landsate satellite scanners with medium (240 m) and high (80 m) resolution and from Salyut orbital station photos with 30 m resolution. Delta development was shown by map series using survey mapping of present conditions as the reference. Scanner photos from earth resources and meteorological satellites were used to map seasonal variations. Photos retaken with the same technology several years later allowed representation and comparison of changes and analysis of dynamics due to hydrodynamic systems and agricultural and reclamation activities, and the identification

of delta movements, appearance of spits and bars and channel variations. Delta histories were studied over longer periods by means of topographic survey maps from the 1940-50's or even 19th century military maps. Geomorphological and landscape characteristics were studied by means of space imagery mapping showing relief features; ground studies identified development stages. The practical value of space imagery for mapping was demonstrated.

UDC 528.7 (202) (73)

COMPREHENSIVE MAPPING OF ARID TERRITORIES OF ARIZONA USING SPACE PHOTOGRAPHY

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA in Russian  
No 3, May-Jun 84 (manuscript received 18 Apr 83) pp 72-77

GLUSHKO, Ye. V. and KONDRAT'YEVA, T. I.

[Abstract] Cartographic work to compile maps of the arid part of Arizona from space photographs is described. Work was done from a picture obtained from the "Landsat-1" satellite on 2 May 1973 using a multispectral scanning system. The picture was taken at a height of 915 km. at a scale of 1:3,360,000 with a spatial resolution of 70 meters and covers an area of 34 square kilometers. [as published] Decoding was done from synthesized color images in the spectral ranges 0.5-0.6 micrometers (green), 0.6-0.7 micrometers (red), and 0.8-1.1 micrometers (near infrared) using a working scale of 1:1,000,000. The initial map, clearly showing the higher belt of the piedmont and the southwest edge of the Colorado Plateau, was used to compile geomorphological, soil, geobotanical and land-usage maps of the same area. Features of the thematic maps are described. It is suggested that the large-scale use of space photography could be useful in compiling photographic maps of the USSR at a scale of 1:1,000,000, similar to the "Photo-Atlas of the United States" published earlier (Pasadena, 1975). It is asserted that the use of space methods facilitates improvements in geographical cartography, which can then also be used to compile thematic maps. Photomapping is acquiring increasing importance in monitoring the natural environment.  
Figures 2: references 8: 5 Russian, 3 Western.

[142-9642]

REPETITION OF DENSE CLOUD COVER ABOVE INDIAN OCEAN FROM GENERALIZED SATELLITE DATA

Leningrad IZVESTIYA VSESOYUZNOCO GEOGRAFICHESKOGO OБSHCHESTVA in Russian  
Vol 116, No 2, Mar-Apr 84 (manuscript received 6 October 82) pp 138-144

ABRAMOV, R. V.

[Abstract] Using as a data base information contained in the USSR Hydrometeorological Center maps compiled during the period 1967-1971 (produced from pictures obtained by Soviet and U.S. satellites for the purpose of petroleum analysis) an attempt was made to determine patterns of repetition in dense cloud cover above the Indian Ocean (latitude 30° south to 30° north, longitude 30° east to 150° east) and the association (if any) between cloud type and cloud cover. It was found that the cloud cover repetition patterns during the survey period (1967-1971) was most marked in the region of the equator, reaching 25-26% between 92° east and 96° east. In the median field cloud cover repetition reached approximately 10.6%. Patterns over the Indian Ocean are compared with similar patterns over the Atlantic and Pacific oceans, and the significance of cloud cover patterns on global thermal flows is discussed. Cloud types were analyzed. It was found that the dominant type overall above the Indian Ocean is cumuliform, which does not usually form dense cloud covers. Dense covers of cumulus dominate in the east equatorial and Arabian Sea zones. Stratiform and cirrus frequently accompany cumulus. It is concluded that most of the dense cloud cover in the southern hemisphere occurs in the equatorial region and that the southern hemisphere is still the major recipient of solar heat. Figures 2; references 16: 11 Russian, 5 Western.  
[133-9642]

## SPACE POLICY AND ADMINISTRATION

### U.S. SPACE POLICY SAID TO SEEK 'ABSOLUTE MILITARY SUPREMACY'

Moscow INTERNATIONAL AFFAIRS in English No 6, Jun 84 pp 61-67

[Article by Y. Tomilim: "To Avert the Threat of Militarizing Outer Space"]

[Text] The first nation to begin peaceful exploration of outer space, the Soviet Union is exerting every effort to prevent outer space from becoming a new area of the arms race. In the 1960s and 1970s, the Soviet Union initiated a number of international agreements which limit the use of outer space for military purposes. Nevertheless, outer space occupies a prominent place in Washington's plans for military supremacy. The United States has proclaimed and actively pursues large-scale preparations for "star wars." The name itself, borrowed from the notorious science fiction movie, indicates that the fantasy of the architects of this campaign has really gone wild.

Outer space is already crammed with reconnaissance and communication satellites which are used by different arms of the U.S. military services. Fred Kaplan, a military observer, writes in THE WASHINGTON POST: "Most of what we know about the Soviet military, especially about its nuclear weapons, comes from satellites. A great deal of military communications, command-control networks, navigational aids and other support systems also are channelled through satellites."

Until quite recently U.S. military programmes considered outer space to be of auxiliary importance, as it were. Today, it is rapidly moving to the foreground, and measures are currently being elaborated, the implementation of which will make outer space a significant military theatre. Specifically, projects are underway in the United States aimed at creating antisatellite weapons systems.

Several years ago, a propaganda campaign was launched in the United States that a "Soviet threat" was enhanced by the existence of Soviet antisatellite weapons for use against American systems, and that the Americans were "lagging behind" in this sphere. This is a routine device employed by the Pentagon every time it needs funds to develop new types of weapons. Having obtained the required money, the appropriate U.S. departments and agencies developed and started testing an antisatellite system based on the use of the F-15 jet for launching from the upper atmospheric layers special self-guiding, two-stage missiles designed to destroy satellites. The system is to be deployed in 1987.

This system frequently referred to by the Western press as first signs of an arms race in outer space can indeed entail irreparable consequences. Sober-minded U.S. politicians have warned that should the United States go further along this track and continue testing the new antisatellite system, the Soviet Union, which in August 1983 announced a moratorium on all launches of antisatellite weapons in outer space, will resume testing its systems and will develop effective antisatellite arms of its own.<sup>2</sup> This will force the United States to upgrade its system, and the arms race in outer space will go unabated.

As far as further possible developments are concerned, the American press has suggested a number of "scenarios" along the following lines: first one side to be followed by the other, or the two sides simultaneously develop antisatellite weapons capable of attacking spacecraft both at high and low altitudes, thus posing a threat to early-warning satellites, i.e., satellites designed to detect ICBM launches. Then the other side either develops a system capable of attacking the enemy's new antisatellite weapons system or produces a combat space station capable of defending satellites. Or it may create both. Then the other side devises a system to attack this weaponry of the enemy. And the story repeats itself all over again.

This may not be the exact picture of what the technological developments might be should the American antisatellite system become operational. The "scenarios" mentioned above, however, are undoubtedly correct in showing the logical chain of possible events, for this was the pattern of the arms race in other spheres.

In any case, having commenced this January testing of the F-15 based anti-satellite system, the United States is already engaged in the development of more sophisticated antisatellite systems, including those with laser weapons for instantaneous destruction of the other side's space targets.

Getting ready for large-scale use of outer space for military purposes, the United States is working on command and control of combat operations in and from outer space. To this end, a space command has been set up within the U.S. Air Force. The Joint Chiefs of Staff is strongly in favour of setting up a joint command of the Army, Navy, Air Force, and Marine Corps to exercise control over military activities in outer space and is working in this direction. This command is to control the flights of military satellites, the military space Shuttle programmes, and the use of space-based antisatellite and antimissile weaponry.

These are still preliminary efforts. The major goal lies ahead. Outer space is viewed by American strategists as a medium for deployment of entirely new weapons systems components which, combined with ground-based arms, nuclear in particular, would finally give the United States the long-awaited "absolute military superiority" in the world and bring it recognition as a major "star power."

In recent years, a group of U.S. hawks under the ideological guidance of the "father of the American H-bomb," Edward Teller, whose misanthropic philosophy

has brought him world-wide notoriety, has been vigorously advocating the development of these new space-based systems. Moreover, these people are working hard to subordinate the current U.S. space efforts to these aims. In particular, great hopes are being placed on the manned spacecraft Shuttle programme. Although the Shuttle programme was launched under the auspices of the National Aeronautics and Space Administration, most of the launches have military missions. Shuttle spacecraft are tested for placing in orbit and creating there military satellites and space stations, for testing various laser guidance and destruction systems, and for direct use against the other side's satellites. The military believe that the technological evolution in this field will pave the way to powerful orbital combat stations with ray weapons designed to destroy targets in outer space and in the atmosphere. This technology makes it possible to develop space-based arms to be used for direct attacks against land-based command and control facilities, military and economic installations, and populated areas.

This line of the U.S. military-industrial complex at large-scale use of outer space for military purposes has acquired a new dimension after President Reagan's televised address on March 23, 1983. His much advertised pronouncement heralded in significant yet rather vague terms a "new military concept" based on the use of outer space for deployment of components of future weapons systems. The President was apparently seeking propaganda effects, for he called the nation to focus its efforts on creating the "means of rendering... nuclear weapons impotent and obsolete."

From further clarifications and amendments made by official spokesman it can be deduced that Washington will work on its new space programmes and, consequently, seeks funds for them under the guise of these programmes creating an "absolutely reliable" antimissile defence of the United States.

An ad hoc commission was even set up on the President's instruction in March 1983 so as to explore possible ways of using lasers with different sources of energy and focussing mirrors for targetting particle beams on board of orbital stations. The American press reports that late last year the National Security Council heard a secret report produced by the commission and decided to speed up the work in this direction.

To stir up a propaganda hullabaloo, occasional information "leaks" are staged about the commission's work. These "leaks" are widely commented on by politicians, scientists, and columnists. Periodically, the American scientific press holds discussions of the advantages and short-comings of various sources of laser beams which could be deployed in outer space as well as of the ways and means of implementing different parts of the future programme.

Obviously, what is meant is the creation of an attack system capable of discriminately destroying the enemy's ICBMs and SLBMs by space weapons based on transmission of energy of electromagnetic waves or particle beams over large distances. The programme is said to become operational within 20 to 25 years.

Officially, the research efforts currently underway in the United States within the framework of the space antimissile defence programme are not related to the antisatellite weapons programme. Some American observers, however, correctly point out that the technologies required by the most sophisticated antisatellite weapons systems are very much similar to those which are needed to bring down ballistic missiles. Therefore, the logic of the arms race of antisatellite weaponry opens up broad opportunities for the proponents of "star wars" who will seek to drag their programmes through the back door should they find themselves banished from the front gate.

Naturally, any antimissile defence system will be meaningful only if it 100-percent effectively covers the entire country's territory. The present nuclear missile arsenals are so large that even if the smallest fraction of missiles succeeds in penetrating the enemy's antimissile defence, it is capable of producing "unacceptable damage" to the other side, to use American terminology. Can there be an absolute ABM system?

The entire progress of military technology from the Stone Age to modern times gives us the definite answer that there is and can be no such a thing as an absolute defence capability. Both defensive and offensive weapons have always been developing as a single whole.

Moreover, the emergence of defence capability prompts the other side to accelerate the development of counter-measures. Who knows, perhaps, the space ABM system, currently under discussion in the United States, is a unique exception to the rule? Or the present level of science and technology has finally made it possible to create such an absolutely impenetrable shield? No and again no. Note even the most zealous proponents of the new American programme dare to claim this. In the course of the discussion around the proposed programme, American experts mention dozens of ways and means which can make the system ineffective. Here are some of them:

destruction of space-based antimissile defence stations by ground-, sea-, air-, or space-based ballistic missiles;

destruction of these stations by powerful ground-based lasers;

emplACEMENT IN THE ORBIT OF ANTIMISSILE DEFENCE SPACE STATIONS OF OBSTACLES moving in such a way that their relative speed is high enough to make space stations inoperative;

false missile launches for the destruction of which space-based ABM stations will use out their energy reserves;

emplACEMENT OF MIRROR-LIKE COATING ON THE MISSILE SURFACE CAPABLE OF REFLECTING LASER BEAMS;

disruption of radio communications between space stations and ground-based command and control facilities, etc.

While listing these or other ways and means of penetrating the space antimissile defence system American experts come to the conclusion that the creation of means for penetrating an ABM system will be far cheaper than the development of the system. It is believed that the costs of these means will be one or two percent of the funds needed for the deployment of the antimissile defence system.

In this case, why should such an expensive system be created at all if it cannot prevent the enemy's missiles from reaching the protected territory? The thing is that all the talk about the defensive nature of the new system is nothing but camouflage designed to conceal its true essence--to contribute towards building up the first nuclear strike potential. Combat laser-equipped space stations are rather vulnerable to an enemy's attacks should it decide to strike first. But these vehicles can effectively be used if the first strike is contemplated by the United States. The architects of this new American programme tend to believe that the space-based antimissile defence system will deprive the Soviet Union of its capability to retaliate and thus will disarm it in face of the American nuclear threat.

Thus, the new USA's space weapons programme fits well in its first nuclear strike doctrine. No matter what a "defensive" tag is affixed to this system, it has been conceived as an aggressive weapon. This is also proved by the fact that in future combat stations of this system can be used for destroying ground-based targets, in particular command and control facilities, that is, for "blinding" the enemy prior to delivering the first strike at him.

There are the American strategists' calculations. It is hardly necessary to talk about the fate of similar calculations in the past. All the present schemes to achieve military superiority over the Soviet Union are doomed to failure. The USSR will never let this happen and will never face any threat unarmed.

Should the United States start down the dangerous road of practical deployment of a new space weapons system, this will seriously damage the overall military strategic stability. While evaluating the possible consequences of the introduction of a large-scale space weapons system many American experts and politicians take note of the fact that its creation would considerably complicate the already cumbersome and fragile mechanism of strategic balance between the USSR and the USA and would enhance the risk of tragic errors in decision-making in a crisis situation.

Suffice it to recall that this is not for the first time that the issue of an antimissile defence system of the United States has appeared on the agenda. It was an acute controversy throughout the 1960s when the military-industrial complex put forward the idea of creating first the Sentinel and then the Safeguard ABM systems. In both cases the advocates of an antimissile defence system were trying to profit by the psychological appeal of the idea to provide protection against nuclear-missile weapons. The idea of creating an ABM system, however, was strongly opposed by the then (1961-1968) Secretary of Defense Robert McNamara, some influential Senators, like James William

Fulbright, Michael Mansfield, Frank Church, Charles Percy, James Symington, etc., and a group of ranking experts on strategic weapons--Herbert York, Jerome Wiesner, George Kistiakowski, Wolfgang Panofski, and George Rathjens.

Their arguments against an antimissile defence system were similar to those advanced today. First of all, they emphasized the tremendous destabilizing strategic effect of these "defensive" weapons. Equally, the fabulous potential costs of each proposed system were mentioned. At that time experts were thinking of the maximum cost of the most reliable system from \$40,000 to \$50,000 million. Today, these figures appear rather modest, for estimated costs of the space-based ABM system go beyond the one trillion mark. Finally, the opponents criticized both proposed systems as vulnerable in military terms. Robert McNamara, for example, arrived at the following conclusion: "...It is important to understand that none of the systems at the present or foreseeable state of the art would provide an impenetrable shield over the United States."<sup>3</sup>

The struggle over the ABM issue ended with the conclusion on May 26, 1972, of the Soviet-American Treaty on the Limitation of Anti-Ballistic Missile Systems. Thus, the United States renounced the creation of a large-scale antimissile defence system. Article I of the Treaty reads: "Each party undertakes not to deploy ABM systems for a defence of territory of its country and not to provide a base for such a defence." According to the Treaty and the joint Soviet-American statement, signed on November 24, 1974, both parties have the right to protect with an ABM system only one region of their territories with a radius of 150 kilometers.

Thus, the very idea of creating a space-based antimissile defence system amounts at least to the intention to violate the 1972 Soviet-American Treaty. Moreover, if this idea is translated into life it will directly violate the Treaty Article V of which specifically emphasizes the intention of both sides "not to develop, test, or deploy ABM systems of components which are sea-based, air-based, space-based, or mobile land-based." By the way, the Treaty is not limited in time (para 1, Article XV).

The U.S. efforts aimed at large-scale use of outer space for military purposes affected the heated discussion of the issue of preventing the militarization of outer space, which took place at the 38th Session of the UN General Assembly in 1983. A solid basis for this discussion was provided by the Soviet initiative to conclude a Treaty on the Prohibition of the Use of Force in Outer Space and from Space Against the Earth. Explaining its reasons, the Soviet Union emphasized that it was guided by the desire to prevent the militarization of outer space and to erect reliable obstacles to various schemes of developing and deploying space weapons systems capable of destroying both space- and ground-based targets.

Guided by the same desire, the Soviet Union proposed at the United Nations in 1981 to conclude a Treaty on the Prohibition of the Stationing of Weapons of Any Kind in Outer Space. This proposal was approved the General Assembly. The U.S. stand on the issue, however, blocked the elaboration of the Treaty.

Therefore, the Soviet Union proposed to the 38th Session of the UN General Assembly to go further and agree on the prohibition of the use of force both in outer space and from outer space against the Earth. At the same time, the USSR spoke in favour of renouncing the idea of new antisatellite systems and of eliminating the existing systems.

Considering that many Western states spoke out in favour of a priority ban on antisatellite systems, the Soviet delegation at the 38th Session of the UN General Assembly declared the Soviet side's readiness also to conduct, if this is deemed helpful, individual negotiations on antisatellite systems, including on a bilateral basis with the United States.

Many delegations supported the Soviet proposal and denounced the U.S. plans to use outer space for military purposes. A Swedish representative said: for example, that his country did not believe that the antimissile ray weapons would ensure stability in the world.<sup>4</sup> His Indian counterpart drew the delegates' attention to the fact that a new menacing threat was looming large on the horizon--the threat of the arms race in outer space.<sup>5</sup>

The 38th Session of the UN General Assembly adopted a resolution in which the Committee on Disarmament is requested to start negotiations on the conclusion of an agreement or agreements on the prevention of an arms race in all its aspects in outer space, with due regard of the Soviet draft treaty on the issue. The resolution was supported by 147 states, with only one country, the United States, voting against. It is noteworthy that all the U.S. allies, except Britain which abstained, supported the resolution. Apparently, their stand was influenced by the fact that the new U.S. space schemes do not take into account the security interests of its allies but run counter to them. Whereas the new American space arms program is allegedly designed at least to lessen a retaliatory Soviet strike after a U.S. first nuclear strike, it totally loses any illusorily "defensive" meaning as regards America's allies. While a "space umbrella," though a holey one, will cover the territory of the USA, its allies can hardly count even on such a cover. After all, even from a purely technical point of view the interception of medium-range missiles is undoubtedly a more complex matter than the interception of intercontinental missiles.

Thus, there is only one sensible alternative to the arms race in outer space--negotiations on an agreement or agreements which must avert this dangerous course of developments. This issue appears on the agenda of the Geneva Conference on Disarmament (till 1984 the Committee on Disarmament) which resumed its work in early February. In the past the United States used to block such negotiations there. If it continues this line, the United States will put itself against the entire international community.

The UN General Assembly also decided that the issue on the prevention of the militarization of the outer space would be discussed by the UN Committee on the Peaceful Uses of Outer Space.

Addressing the constituency of the Kuibyshevsky electoral district of Moscow on March 2, 1984, Konstantin Chernenko emphasized that the United States could contribute greatly to stronger peace by accepting an agreement renouncing the militarization of outer space. "As is well known, the USSR has long been proposing this."

With the presidential elections approaching, the U.S. Administration has been giving itself off of late as a "peace-maker," making assurances of its desire for a dialogue with the Soviet Union. However, these assurances are fully contradicted by its practical actions, including those in the sphere of the militarization of outer space. Submitting on March 31, 1984, a report to Congress on Administration policy on control of antisatellite systems, President Ronald Reagan stated in a covering letter that he was against entering into official international negotiations on this issue. Thus, though declaring its desire for "dialogue in general," the U.S. Administration rejects this dialogue as soon as it comes to concrete questions.

In a bid to justify this refusal, the U.S. President alludes to the "considerable difficulties" involved in the verification of compliance with measures in regard to antisatellite weapons. These notorious "verification difficulties" have long become a traditional excuse for the USA for sidestepping disarmament measures. In the said instance such allusions are particularly odious, inasmuch as the antisatellite systems have not yet passed the testing stage, and it is common knowledge that it is far simpler to reach agreement on measures to limit armaments, including verification of these measures, before these armaments are tested, perfected, put into production and deployed.

Incidentally, having released this "camouflage smoke," the U.S. Administration is in effect acknowledging both in the covering letter and the report itself that the United States does not want a ban on antisatellite weapons, since it needs them to keep Soviet satellites in its sights. "Quite bluntly and frankly--they do not want to negotiate," was how Konstantin Chernenko evaluated this position of Washington in a PRAVDA interview. To sweeten the pill, Ronald Reagan has made vague promises to study a number of alternatives in arms control in outer space, meaning possible negotiations with the Soviet Union, if such negotiations serve the interests of the United States. This stipulation is highly characteristic: the current Administration unambiguously interprets "U.S. interests" to mean "military superiority for the USA," and it is evidently for this reason that it does not consider it necessary to speak of the possibility of mutually acceptable decisions. As to the alternatives themselves, it is clarified that the United States is "studying the possibility" of individual "more modest versions" of limitation "on a selective basis" of specific types of space weapons systems and activity in outer space.

Meanwhile, at the Geneva Conference on Disarmament the USA continues to block the start of talks on averting an arms race in outer space. This American stand is evoking increasing criticism in many countries, Western ones included. The world is increasingly coming to realize the danger to all nations and states emanating from the imperialist course of the United States, which is intent on turning outer space into a new arms race arena.

The adoption of practical measures to eliminate this danger cannot be put off. Accord in the prevention of the militarization of outer space, along with other measures in arms limitation and disarmament, could help normalize the international situation and reduce the threat of the catastrophe of war.

#### FOOTNOTES

1. THE WASHINGTON POST, Oct 16, 1983.
2. The Soviet Union has pledged not to be the first to place any antisatellite weapons in outer space. In other words, it has unilaterally introduced a moratorium on such launches, which will be in effect throughout the time other states, the United States included, refrain from placing in orbit antisatellite systems of any type.
3. Address made before the annual convention of United Press International editors and publishers at San Francisco, California, on September 18, 1967.
4. See UN Doc. A/C. 1/38/PV.4 of October 18, 1983. ,
5. See UN Doc. A/C. 1/38/PV.13 of October 25, 1983.

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KRASNAYA ZVEZDA COMMENTARY ON U.S. MILITARY SPACE POLICY

Moscow KRASNAYA ZVEZDA in Russian 23 May 84 p 3

[Article by Col-Engr M. Rebrov: "Adventurism in Space"]

[Text] "Star Wars," "Armadas of Battle Stations in Space," "Project 'Talon Gold'," "Laser Duel," "High Frontier," "Defense of Our Freedoms"--these are only part of the names of projects that are being nurtured in the militaristic circles in Washington and financed generously by the administration. In the last 2 decades, \$50 billion has been spent on military space programs and almost another \$15 billion is planned to be spent in the near future. The reason is this: "...the frontiers of American vital interests now lie in the depths of space...." "...the Soviet military threat must be eliminated."

The head of state goes on television. His words sound grandiloquent, even if somewhat theatrical: "Let me share with you a dream of the future that promises hope." The orator pauses and then continues: "It is that we are starting on a program to counteract the dangerous missile threat with facilities that are defensive ones."

President Reagan intentionally stressed the words "dangerous" and "defensive," obvious calculating that the cost figures for his projects that he then cited would not seem so high. However, the President's reasoning about a "defensive space shield," his "peace-loving" rhetoric and "political maneuvering" was not able to distract soberly thinking Americans from the main question. It was also asked in the pages of THE NEW YORK TIMES by a member of the House of Representatives from California, Democrat Fortney Stark: "If the Soviet Union were the first to put such a system in place, would we--like President Reagan--regard it as a defensive step that does not threaten our security?" And the same congressman answered: "Of course not!"

Another member of the US Congress's House of Representatives, M. (Livayn), came out with the demand that the White House abandon its military adventures in space immediately. "We stand on the threshold of a new round in the arms race," he announced, pointing out the total flimsiness of the President's statements that the large-scale system being created by the Pentagon is allegedly for defensive purposes.

The militarization of space that is being carried out by the Pentagon with the full support of the present American administration is causing sharp protests

in different countries throughout the world, including the United States. This is indicated by a letter from the eminent American scientists R. Garvin and C. Sagan to K.U. Chernenko, general secretary of the CPSU Central Committee and chairman of the Presidium of the USSR Sup. e Soviet. However, in Washington they are ignoring these sensible warnings and continuing to work on "star wars" scenarios, introducing all new characters and subjects in them all the time. Lieutenant General G. Abrahamson, who was recently named as director of the program for the creation of the antimissile defense system with space-based elements, said that "President Reagan's concept includes not only the United States and its allies, but also the neutral countries of Europe." That means that others are being drawn into this adventure in space.

In Washington not too long ago, an announcement was made about the creation of a "special space technology center," which has been ordered to give special attention to the most recent technology for the purpose of developing military systems for use in space. The veil of "decency" has also been raised over a special space station in which the Pentagon is extremely interested. "This Hollywood version," noted the WASHINGTON POST, "differs considerably from the manned spacecraft tha. Ronald Reagan sanctioned to be built."

No matter how refined Western propaganda becomes in its attempts to justify the "philanthropic" aspirations of the chief in the White House, a fact remains a fact: the space antimissile system, as it is contemplated in Washington, is intended not only to destroy the "enemy's" satellites and missiles after they are launched. Strategists in the Pentagon are also hoping for impunity during the infliction of a first (!) strike.

The falsity of Reagan's position is also refuted by the opinion of D. Pike, a member of the Federation of American Scientists, that antisatellite weapons are "a key element of a first strike potential." In a word, the "space shield" is an attempt to cover up the "nuclear sword." And all of this is being done in an atmosphere of hysteria and quite tiresome verbiage about an imaginary "Soviet military threat." As far as a war in space is concerned, as R. Garvin announced, it is not an alternative to war on Earth but a prelude to it.

Militaristic hysteria cannot be covered up with a blanket of cheap demagoguery. All of Reagan's arguments about "peaceful aspirations" are lost among the revelations of the President's assistants. G. Keyworth confirms that space weapons to fight Soviet satellites can be ready as early as the end of the 1980's, and Pentagon representatives participating in flights in shuttle craft under the "Space Shuttle" program declare that "space is a place from which the whole world can be kept in fear." That is the essence of the "defensive" concept.

Man's subjugation of space and assault on its depths, his attack on nature's secrets, and the use of space and rocket technology in the interests of Earth's peoples and in the name of science belong to that set of problems that is now called "global." The meaning of this term is not only that the expanses of the Universe are limitless. The main and most essential point is that the solution of this problem is of vital importance for all living beings on our planet and all the countries and peoples in the world, and can be solved only as the result of the joint efforts of all mankind. K.E. Tsiolkovskiy wrote about this

as long ago as the beginning of the century. And when Yuriy Gagarin completed his historic voyage in the legendary "Vostok," the entire world heard the words he addressed to all progressive mankind: "We consider our triumphs in conquering space to be an achievement not only of our people, but of all mankind. We happily place them at the service of all peoples, in the name of progress and the happiness and welfare of all people on Earth. We place our achievements and discoveries not at the service of war, but at the service of peace and security for the Earth's peoples."

All the honorable people on this planet took to heart these words, in which there were an appeal, a vow and faith in the intelligence of both this and future generations.

More than a quarter of a century ago, the Soviet Union opened a way into space for mankind. The launching of the first satellites and automatic lunar stations and Yuriy Gagarin's flight gave an unambiguous and clear answer to any conjectures about the relative technical capabilities and level of development of Soviet science. And in those years, despite the definite advantage that the USSR had over other states--the United States, first of all--it was the country that came out with the proposal to prohibit the use of space for military purposes. Our first action took place in March 1958, when this question was raised in the United Nations. In subsequent years we continued, with the same persistence, to undertake efforts in this direction.

Our efforts were interpreted somewhat differently by evil-wishers in the West. There is certainly no sense in presenting all these conjectures here. They are distinguished by a lack of logic, a malicious tone and falsity of argumentation. Let us remind the reader only that the USSR's position relative to war in space--or from space--always was and remains unambiguously negative. And this is not because the Soviet people fear such a war more than others. This position emanates from our country's general and fundamental approach to the problems of war and peace.

Examples? There are plenty of them. And all of them are manifestations of good will and the deepest humanism. For instance, the Treaty on the Prohibition of Nuclear Weapon Testing in the Atmosphere, in Space and Under Water, which was concluded in 1963 on the initiative of the USSR, placed outside the law the conduct of nuclear test detonations in space.

The Treaty on the Principles of Activities of States for the Investigation and Utilization of Space, Including the Moon and Other Heavenly Bodies went into effect on 10 October 1967. The contents of this document, which many, many countries have now signed, are permeated with the idea of insuring the peaceful orientation of all experiments in space. Those who signed the treaty took upon themselves the direct obligation of entering space only "in the interests of supporting international peace and security and the development of international cooperation and mutual understanding." This, also, was an initiative of the USSR.

Further, the provisions of this document concerning the complete demilitarization of space were specified and developed in an agreement on the Moon that,

again on the initiative of the USSR, was worked out and approved by the UN General Assembly in 1979.

In December 1981, the UN General Assembly called upon the Committee on Disarmament to begin talks and work out an international agreement prohibiting the placement of weapons of any kind in space. By its own decision, the world community of nations supported the idea, as advanced by Soviet leaders, of the necessity of joint efforts in order to achieve a great and human goal: to make the boundless ocean of space clean and free of weapons, no matter what kind they might be.

In 1983, the USSR undertook a new peace initiative by proposing for inclusion in the agenda of the UN General Assembly's 38th Session the question "On Concluding a Treaty to Prohibit the Use of Force in Space and From Space Toward the Earth." A draft of this document was presented at the same time. All of this received the approval of the world community.

That is the USSR's position.

And here is the position the United States has been occupying all these years. As long ago as the end of the 1950's, soon after the Soviet Union launched the first artificial Earth satellite, the United States began developing anti-satellite weapons (the "Saint" project). In April 1959, the Pentagon began testing "Bold Orion" antisatellite missiles, which were launched from B-47 bombers; 1962 saw the announcement of the High Altitude program, which provides for the use of F-4 fighters as launching platforms; a year later, work began on the development of an antisatellite system based on "Nike-Zeus" rockets. More was done after that. By 1977 the number of military satellites (intelligence, navigational, special communications and so on) exceeded 150. The Pentagon continued to increase the launch rate, and in the last decade and a half [sic] this figure, which was not small to begin with, rose to 800. Now they are talking about hundreds of new "killer satellites."

In Moscow on 26 May 1972, the USSR and the United States signed a permanent treaty on limiting antimissile defense systems that the present US administration is trying to belittle in every way possible. Moreover, the Soviet-American talks on antisatellite systems that were begun in 1978 were broken off by the American side a year later. And now Reagan is now advancing yet another turn along the arms race spiral, which is extending into space.

It is a dangerous venture.

"The Soviet Union is a resolute opponent of competing in a race for any weapons, including those for use in space," emphasized Comrade K.U. Chernenko in response to the appeal of the American scientists. "At the same time, it must be understood that in the face of a threat from space, the Soviet Union will be compelled to take measures in order to guarantee its own security reliably. Calculations that the road to military supremacy can be laid in space are based on illusions. However, they do not wish to relinquish those calculations, and this is fraught with extremely dangerous consequences. Preventing such a course of events while it is still not too late is the direct duty of

responsible statesmen, scientists and everyone who is truly concerned about the future of mankind."

Space must not become a new sphere for military adventures.

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## LAUNCH TABLE

## LIST OF RECENT SOVIET SPACE LAUNCHES

Moscow TASS in English or Russian various dates

[Summary]

| Date      | Designation              | Orbital Parameters   |         |               |             |
|-----------|--------------------------|--|---------|---------------|-------------|
|           |                          | Apogee   | Perigee | Period        | Inclination |
| 16 Aug 84 | Cosmos-1590              | 293 km   | 221 km  | 89.3 min      | 82.4°       |
| 24 Aug 84 | Molniya-1                | 40,877 km  | 467 km  | 12 hrs 17 min | 62.8°       |
|           |                          | (Communications satellite for long-range telephone, telegraph and broadcast of Central TV programs to points in the "Orbita" network)  |         |               |             |
| 24 Aug 84 | Ekran                    | 35,580 km  | --      | 23 hrs 45 min | 0.4°        |
|           |                          | (Communications satellite for relay of Central TV in decimeter band to network of collective use receivers; near-stationary, circular orbit; international registration index: Statsionar-T) |         |               |             |
| 30 Aug 84 | Cosmos-1591              | 300 km   | 220 km  | 89.4 min      | 82.3°       |
|           |                          | (For study of earth's natural resources; data goes to State Research and Production Center "Priroda" for processing and use)   |         |               |             |
| 4 Sep 84  | Cosmos-1592              | 380 km   | 209 km  | 90 min        | 72.9°       |
| 4 Sep 84  | Cosmos-1593,<br>-94, -95 | 19,141 km  | --      | 11 hrs 16 min | 64.7°       |
|           |                          | (3 satellites launched by single booster; to test elements of a space navigation system to locate USSR civil aircraft and ships of merchant and fishing fleets; near-circular orbits)        |         |               |             |
| 7 Sep 84  | Cosmos-1596              | 39,342 km  | 613 km  | 11 hrs 49 min | 62.8°       |

| Date      | Designation | Orbital Parameters  |         |               |             |
|-----------|-------------|---|---------|---------------|-------------|
|           |             | Apogee  | Perigee | Period        | Inclination |
| 13 Sep 84 | Cosmos-1597 | 272 km  | 219 km  | 89.1 min      | 82.3°       |
| 13 Sep 84 | Cosmos-1598 | 1,029 km  | 987 km  | 105.2 min     | 83°         |
| 25 Sep 84 | Cosmos-1599 | 275 km  | 179 km  | 88.7 min      | 67.2°       |
| 27 Sep 84 | Cosmos-1600 | 404 km  | 215 km  | 90.4 min      | 70°         |
| 27 Sep 84 | Cosmos-1601 | 521 km  | 477 km  | 94.5 min      | 65.8°       |
| 28 Sep 84 | Cosmos-1602 | 680 km  | 648 km  | 97.8 min      | 82.5°       |
|           |             | (To provide data and continue testing of new types of measurement equipment and methods of remote study of the world ocean and the earth's surface in the interests of science and branches of the national economy; data goes to the State Scientific Research Center for Study of the Environment and Natural Resources and to autonomous data receiving points of the State Committee for Hydro-meteorology for processing and distribution) |         |               |             |
| 28 Sep 84 | Cosmos-1603 | 877 km  | 852 km  | 102.2 min     | 71.2°       |
| 4 Oct 84  | Cosmos-1604 | 39,342 km   | 613 km  | 11 hrs 49 min | 62.8°       |
| 10 Oct 84 | Cosmos-1605 | 1,031 km  | 969 km  | 104.9 min     | 82.9°       |

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- END -

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**DATE FILMED**

28 Nov 1984